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The Editorial Committee of the Imperial Council of Agricultural Research, India, takes no responsibility for the opinions expressed in this Journal

FIG. 1. Heads of 'blue' wheats (No. 1, 2, 4) and dwarf hill-wheat (No. 3)

FIG. 2. Rachides, empty glumes, palea and kernels of 'blue' wheat (No. 1) and dwarf hill-wheat (No. 2) ($\times \frac{2}{5}$)

ORIGINAL ARTICLES

THE CYTOLOGY OF 'BLUE' WHEAT HYBRIDS

BY

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AND

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(Received for publication on 8 January 1942)

(With Plate XXVI and 21 text-figures)

WHEAT is the most popular crop in north China. It is next in importance to rice in the southern and south-western provinces of the Yangtze alley. Practically all of the important cultivated varieties belong to *T. ugare*. The information regarding the existence of *Emmer* wheats and other ecies of *vulgare* group is rather meagre. As reported by various workers Iosono, 1935, 1 ; King, 1934 ; Shen, 1937] varieties of *T. durum* have been own in some localities in Yunnan, Hupeh, and Sinkiang and those of *T. rgidum* in Sinkiang, Honan and Kansu. It was not until our recent igration to Szechwan, after the Sino-Japanese hostilities, that we realized e significance of the so-called ' blue ' wheat of Szechwan as a distinct group *Emmer* wheats.

Many different local names are given to them and 'blue' wheat is the most pular and collective one. It is so named because the bloom or wax deposited the surface of the green tissues appears bluish in colour. Another closely ated form of *Emmer* wheats in Szechwan is known as dwarf hill-wheat. It fers primarily from the 'blue' wheat in the absence of waxy substance, in a ver plant stature, and in a somewhat different head type ; yet both yield urs of extraordinarily poor quality. Information regarding the habitats these wheats, as reported from various sources, seems conflicting. In some ces they are suited to dry regions or mountain slopes, while in other places y grow well on moist, damp soils, such as river valleys. Therefore, inions differ as to the botanic position of these wheats. Some state them be *T. turgidum* and others *T. durum*. So far as the writers are aware, no ological work on these two forms of *Emmer* wheats has yet been done. is paper reports an inquiry into the identification of these wheats by means cytological studies on various ' blue ' wheat hybrids.

GENERAL DESCRIPTION

A. *Geographical distribution.* ' Blue ' wheat is found to be cultivated as a iter crop in various districts of western and north-western Szechwan. Its tivation in this province goes back a long way and no exact evidence of the e of its introduction is available ; but the limited degree of morphological l physiological differentiations or variations suggests that its introduction ht not be of remote antiquity.

The dwarf hill-wheat, as indicated by the name, is commonly cultivated g the hillsides of the mountainous regions of western Szechwan. Although

no actual data concerning the acreage or production of these two forms (wheats in Szechwan is available, it has been estimated that they probabl constitute about 5 per cent of Szechwan's wheat crop.

B. *General morphology*. In Szechwan where winters are mild 'blue' whe (including dwarf hill-wheat) is customarily fall-sown. Within our collectic there appear a number of varieties with different seedling habits. Amon 249 strains of 'blue' wheat studied, 210 strains assume the upright, sprir habit; 21 prostrate, and 18 semi-prostrate type. All the nine strains of dwa hill-wheat possess upright seedlings. They seldom stool or tiller. Tl number of tillers varies from four to seven per plant. The leaves are usual broad and smooth but possess a peculiar whitish green colour with an ex tremely harsh cuticle. As a rule, the culms are somewhat taller (except dwa hill-wheat) than those of common wheats, ranging from 0·915 to 1·515 mm and hence the tonnage of green material produced per unit area tends to l great. This is, perhaps, one of the reasons why in some localities in Szechwa it is preferred for hay. The straw is of medium stiffness, with a dull, thic striate surface.

So far we have not observed any 'blue' wheat which is beardless. Tl ears average 9 cm. in length and 1·5 cm. in width, possessing 20 or mo spikelets. Three to five florets are found in each spikelet and generally thr are fertile. Most varieties have short, thick, compact heads which are lateral compressed and more or less rectangular in cross section. The rachis tough, smooth, but copiously fringed along its edges with white hairs and bea a frontal tuft of similar hairs at the base of each spikelet, reaching approx mately a length of 3-4 mm. The empty glumes are white, pubescent on bo surfaces and prominently and sharply keeled at the base. The awns are stou rough, grayish white in colour, triangular in section, erect and projectir upward.

The grains are usually amber or yellow, but occasionally pale red i colour, large, broad and plump with a high dorsal arch or hump behind tl embryo. The endosperm is opaque and starchy although in a few varieti it is quite hard and vitreous. A majority of varieties possess an intermedia condition, the texture is rather hard while opaquely white and non-transluce assuming a porcelain-like structure rather than starchy fractures. Howeve when they are grown under more or less humid conditions they are almo starchy.

As already pointed out above, 'blue' wheat is characterized by i waxy appearance. All of our collection except nine are waxy; the bloo covers all the plant parts. Those possessing no waxy bloom (here designat as 'dwarf hill-wheat') have very short, thick-walled culms with ligh yellowish green foliage. The ears are fully bearded, with medium length ar density. With the exception of the ear type, the morphological characteri tics and the growth habit suggest that the so-called dwarf hill-wheat is mo probably a related form of *T. pyramidale.*

C. *Cultural characteristics, quality and disease reactions.* As 'blue wheat tillers less than the common winter wheat, seeding is, therefore, som what heavier than for common wheats. It grows rapidly and the heavil fully bearded heads tend to have a nodding habit; this together with tl

ically bloomy appearance makes them look like a fish tail and thus the ne 'fish-tail' wheat is given by the farmers in certain localities.

The vigorous vegetative growth is accompanied by a delay of development. ieads about a week later than the late varieties of common winter wheats l consequently matures later. Such an inherently long period of growth uld, in part, account for its high yielding capacity. But its tall growth l late ripening may be more readily subject to attacks by birds than ordinary wheat. The straw is moderately stiff so that it is possible for ds to perch upon it and, because it is tall, it ranges above all other wheats l is more conspicuous to the eyes of the birds. It requires a moderately , hot season for satisfactory growth and thus it is more drought-tolerant. e hardness of the kernels is conditioned by the environmental factors.

As shown in our data on nitrogen determination (Table I) it may be said in eral that 'blue' wheat tends to contain more protein than other wheats nmonly cultivated in Szechwan, especially when the environment is favour-e. Yet the baking quality of 'blue' wheat and dwarf hill-wheat flours ather poor. Their gluten is less elastic than that of common wheats and ir swelling capacity and the gas-retention capacity are unexpectedly low. ey yield a heavier and stiffer dough with comparatively less water than er flours. Probably the gluten of 'blue' wheat as well as its starch differs ysico-chemically from that of other wheats. This is the reason why flour m 'blue' wheat is primarily used in the baking of cakes and biscuits.

TABLE I

Protein content of wheats

(1940-41 crop from the University Farm, Chengtu, China)

Varieties	Moisture (per cent)	Protein (per cent)
) ('blue' wheat)	15·99	11·79
. ('blue' wheat)	15·28	12·20
: ('blue' wheat)	16·86	9·37
: (dwarf hill-wheat)	17·32	10·89
. 2905 (common wheat)	14·62	10·60
.4197A (common wheat)	15·51	10·20

* Improved varieties of the University Farm

None of the 'blue' wheat strains tested escapes from the infection of stripe , *P. glumarum*, which is rather serious in the west Szechwan plain, yet e of them reaches a severe stage of infection. They are more or less eptible to loose smut, *U. tritici*, in most localities and, stinking smut, *ritici*, in certain districts. Scab, caused by *Gibberella saubinetii*, is of occurrence in Szechwan but, according to the writers' experience, these e' wheats when sown in Kweichow, (a neighbouring province south of hwan) where wheats are generally harvested one month later than in hwan, suffer rather seriously from the attack of scab fungus. It is ested that the compact spike of 'blue' wheat with heavy tufts of hairs ach rachis joint slows down the rate of drying after rains or heavy dews consequently facilitates the attack of the pathogene. Wu [1940] tested

for the resistance of 'blue' wheat varieties to flag smut, *Urocystis tritici*, by art
ficial inoculation and found that none of the varieties tested was not immun
They are generally more susceptible, particularly those of soft varieties,
damage by flour moth and grain weevil than the common bread wheats und
storage conditions.

Cytological observations reveal that the typical 'blue' wheat as well
the dwarf hill-wheat possesses normally 14 bivalents in meiosis (Fig.
The peculiarities of 'blue' wheat as a district group and its doubtful bota
position appear to justify a study of these subjects on which little literature
available. The present discussion rests primarily upon as yet incompl
information on the cytological behaviours of the hybrids between 'blue' wh
and other known species of *Triticum*.

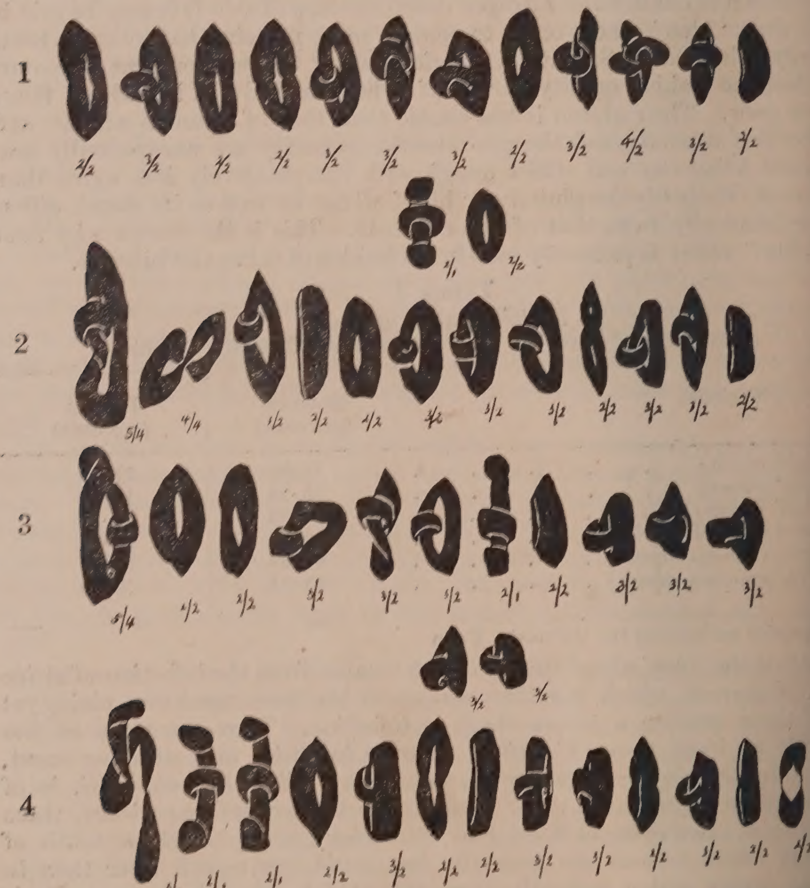
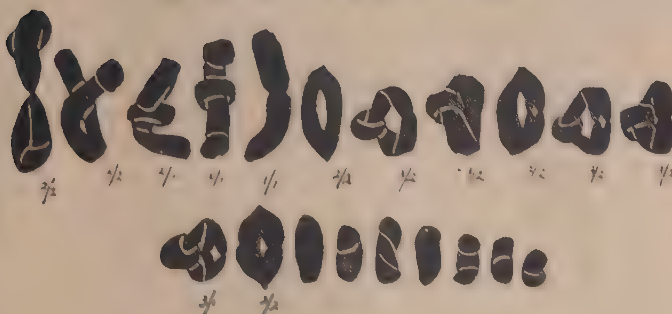


FIG. 1. Chromosomes of metaphase I in 'blue' wheat showing 14 bivalent
FIG. 2. Two rings of 4 and 10 bivalents in *T. durum* × 'blue' wheat
FIG. 3. A ring of 4 and 12 bivalents in *T. turgidum* × 'blue' wheat
FIG. 4. A chain of 4 and 12 bivalents in *T. pyramidale* × 'dwarf hill-wheat



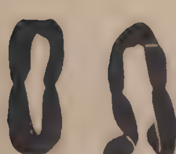


FIG. 5. Metaphase I in *T. vulgare* × ' blue ' wheat showing 1 (IV) + 1 (III) + 9 (II) + 10 (I)

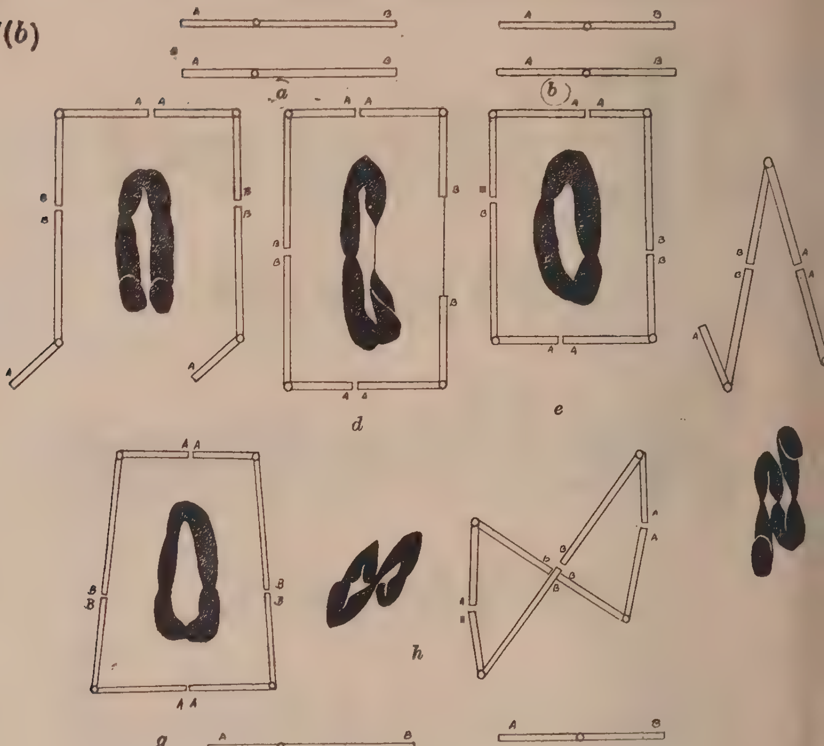
FIG. 6. Metaphase I in *T. sphaerococcum* × ' blue wheat ' showing 2 (III) + 11 (II) + 7 (I)

FIG. 7 (*a*). Association of 4 in *T. durum* × ' blue ' wheat. All the four members possess sub-median centromeres

MATERIAL AND METHODS

The material used in the crosses includes *T. durum* Desf. (var. Iumillo) *f turgidum* L., *T. pyramidale* var. *recognitum* Perc., *T. vulgare* (NK 2905) Hst., *T. sphaerococcum* Perc. and ' blue ' wheat and dwarf hill-wheat col- ed in Szechwan.

7(b)



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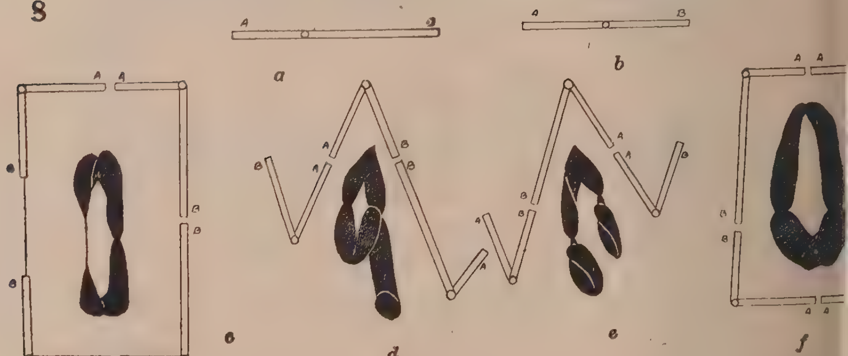


FIG. 7 (*b*). Configurations of *T. durum* × 'blue' wheat ; a and b, two p diagrammatic chromosomes taking part in the multiple configur one pair with median centromeres and the other pair with sub-m centromeres ; c—h, associations of four found from different They are composed of the same chromosomes

FIG. 8. Configurations of *T. turgidum* × 'blue' wheat ; a and b, two p diagrammatic chromosomes taking part in the multiple configur one pair with median centromeres and the other pair with sub-r centromeres ; c—f, multiple associations found from different They are composed of the same chromosomes. The two sets o chromosomes in the two hybrids are morphologically similar

The crosses were made in 1940 and the slides were prepared in 1941. Smears were fixed in La Cour 2BE and were stained by Newton's gentian violet iodine method. Drawings were made with the aid of camera lucida.

Results

A. *Tetraploid hybrids*

1. *T. durum* × B. W., (' blue ' wheat). Besides the bivalents there are two rings of four chromosomes in this hybrid. One of the rings is composed of four chromosomes with sub-median centromeres (Fig. 7*a*), and the other comprises two chromosomes with median centromeres and two with sub-median centromeres (Figs. 2 and 7*b*). The average number of associations of four is 0·9 (Table II).

Bridges (Fig. 9) are observed in the first anaphase. The percentage of bridges is equal to 4·88 and the coefficient of hybridity is 0·00161.

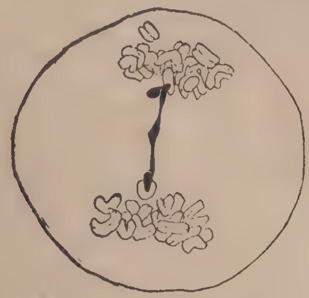


Fig. 9. First anaphase bridge in *T. durum* × ' blue ' wheat

TABLE II

Configurations of tetraploid hybrids

Configurations and No. of X-ta	Bivalents					Multiple configurations				Number of cells observed
						Association of four			Association of 3+1	
	4·2	3·2	2·2	2·1	1·1	5·4	4·4	3·3	2·2	
Durum × B. W.	..	54	182	1	9	2	11	4	..	20
(per cent)	..	21·7	74·2	0·4	3·7	..	..	..	..	..
Turgidum × B. W.	4	119	78	3	..	1	1	..	8	16
(per cent)	2·0	58·3	38·2	1·5	..	..	..	..	..	..
Pyramidale × D. H. W. (per cent)	..	74	38	5	5	..	4	5	..	10
	..	60·6	31·1	4·1	4·1	..	..	..	..	..

TABLE III

Distribution of chiasmata of tetraploid hybrids

Hybrids	Mean No. of bivalent	X-ta per bivalent	X-ta per potential bivalent	Total X-ta per cell	Terminal X-ta per cell	Coefficient of terminalization
Durum × B. W.	12·30	2·18	2·15	30·15	27·30	0·905
Turgidum × B. W.	12·75	2·62	2·50	35·00	26·81	0·766
Pyramidale × B. W.	12·20	2·57	2·46	34·40	26·50	0·770

The mean number of bivalents per cell is 12·30. The number of chiasmata per bivalent is 2·18 and that for each potential bivalent is 2·15. The mean number of chiasmata is 30·15 and the coefficient of terminalization, 0·905.

2. *T. turgidum* × B. W. There is only one multiple configuration which is most frequently an association of three and occasionally an association of four (Table II; Figs. 3 and 8). In the latter there are two chromosomes possessing median centromeres and two possessing sub-median centromeres.

Both the first and the second anaphase of this hybrid are normal. The average number of bivalents per cell is 12·75. The mean frequency of chiasmata per bivalent is 2·62 and that for each potential bivalent, 2·50. The mean frequency of chiasmata per cell is 35·00. The coefficient of terminalization is 0·766.

3. *T. pyramidale* × D. H. W. (dwarf hill-wheat).* There is only one association of four chromosomes (Fig. 4). The number of chiasmata per potental bivalent is 2·46 and that for each individual cell is 34·40. Out of 48 first divisions there are two single bridges (Fig. 11) in the same cell and five single bridges (Fig. 10) in 146 second divisions forming a percentage of 3·61. The coefficient of hybridity is 0·00105 showing that dwarf hill-wheat differs from *T. pyramidale* by a small portion of inversion.

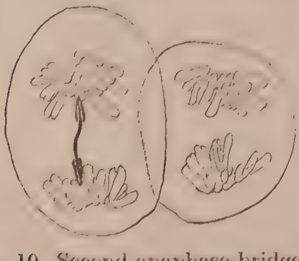


FIG. 10. Second anaphase bridge in *T. pyramidale* × dwarf hill-wheat

FIG. 11. Two single first anaphase bridges in *T. pyramidale* × dwarf hill-wheat

* The cross was made by C. K. Chan, to whom the writers are indebted

Pentaploid hybrids

1. *T. vulgare* (NK 2905) × B. W. There are two multiple configurations, ssociation of four and an association of three (Tables IV and V; Fig. 5). average number of bivalents per cell is 11·9 and the mean number of ·alents per cell is 8·8. The average number of chiasmata per potential lent and that for each cell are 2·14 and 30·40 respectively. The co- ient of terminalization is 0·77. The percentage of bridges in the first sion (Figs. 12 and 13) is 8·33 and the coefficient of hybridity is 0·00278.

'IG. 12. First anaphase bridge in *T. vulgare* × 'blue' wheat

FIG. 13. First anaphase bridge and a fragment in *T. vulgare* × 'blue' wheat

TABLE IV

Configurations of pentaploid hybrids

nfigurations and No. of X-ta	Bivalents				Multiple configurations				No. of cells observed
					Association of four			Association of three	
	4	3	2	1	5	4	3	2	
re × B. W. . .	2	58	43	16	1	1	1	4	10
vcoccum × B. W. .	2	20	31	5	..	1	1	3	5

TABLE V

Distribution of chiasmata of pentaploid hybrids

ybrids	Average No. of bivalents per cell	Average No. of univalents per cell	X-ta per potential bivalent	X-ta per cell	Coefficient of termina-lization
e × B. W.	11·9	8·8	2·14	30·40	0·77
ococcum ×	11·6	8·4	2·11	29·60	0·68

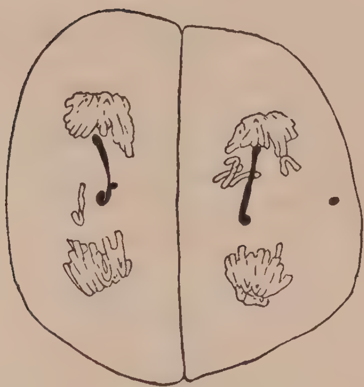


FIG. 14. Second anaphase bridges and fragments in *T. Sphaerococcum* × 'blue' wheat

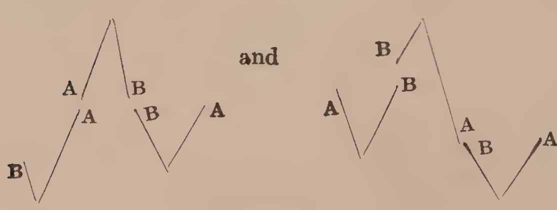
2. *T. sphaerococcum* ×B. Two associations of three (6) are found in the same The average number of uni lents is 8·4 (Table V). number of chiasmata per tential bivalent and that each individual cell are 2 and 29·60 respectively. coefficient of terminalizatio 0·68. The coefficient of bridity evidenced by the oc rence of bridges (Fig. 14 0·00135.

Discussion

A. Configurations

1. *Tetraploid hybrids.* The 17 multiple configurations found in 20 Cs. of *T. durum* × B. W. are exclusively associations of four. More 76 per cent of the latter are ring-shaped and the remainder are chains o either in the shape of N or of an open ring.

In *T. turgidum* × B. W. the multivalents are most frequently associ of three. The one which fails to pair is always the one of the two with median centromere. For the association of three only two combination common, i.e.



In *T. pyrami* D. H-W. the m configuration i ways an assoc of four. Amo cells studied on is devoid of an association o instead of whic bivalents are p

2. *Pentaploid hybrids.* In *T. vulgare* × B. W. only two cells poss 14 (II)+7 (I) are found. Among the six cells possessing multiple configur four show apparent reduction of chiasma frequency as well as increase number of univalents ; showing that the formation of multiple configur

must have something to do with the decrease in the number of chiasma frequency and the increase in the number of univalents. These will be dealt with in later paragraphs.

In *T. sphaerococcum* × B. W. none of the five cells examined show more than 13 bivalents. The combinations of the configurations are mostly 13 (II)+ 9 (I), 1 (IV) + 12 (II) + 7 (I), 1 (III) + 11 (II) + 10 (I), 2 (III) + 11 (II) + 7 (I), and 1 (IV) + 11 (II) + 9 (I). The maximum number of associations of three is two and in the same cell the number of univalents is seven showing that there is intrahaploid pairing owing to external interchanges.

The formation of multiple configurations in the hybrids mentioned in this paper is all due to external interchange and this had been proved in the following ways :—

(*a*) Formation of bivalents in haploid plants of wheats—thus the number of bivalents was found to be one in *T. monococcum* [Kihara and Katayama, 1933 ; Chizaki, 1934], three in *T. durum* [Kihara, 1936]. In *T. vulgare* the number of bivalents was found to be one to two [Gaines and Aase, 1926], three [Yamamoto, 1936], four [Yamasaki, 1936] and nine [Krishnaswamy, 1939]. Krishnaswamy even found an association of three.

(*b*) Multiple configuration in pure species—thus in *T. turgidum*, Darlington [1931, 1] found an association of four.

(*c*) Intrahaploid pairing in intergeneric hybridization—in intergeneric hybrids a part of the bivalents is due to intrahaploid chromosome pairing in *Triticum*. Bivalents were found in *T. turgidum* × *Haynaldia villosum* [Berg, 1934], and in the hybrids between *T. turgidum* and species of *Aegilops* [Percival, 1930].

T. durum showed bivalents on hybridization with *Ae. ventricosa* [Katayama 1931 ; Matsumoto, 1933] and with *Secale cereale* [Kagawa and Chizaki, 1934 ; Plotonikowa, 1930].

Bivalents were also found in *Ae. ovata* × *T. vulgare* [Kattermann, 1932], *T. vulgare* × *Secale cereale* [Aase, 1930] and *Ae. ovata* × *T. sphaerococcum* [Percival, 1930].

(*d*) Intra or intergenomic pairing in intrageneric hybridization—Thompson [1926] found no multiple configurations in *T. monococcum* × *T. turgidum*. In *T. durum* × *T. monococcum* only a trace of multiple association was found [Aase, 1930]. In *T. vulgare* × *T. monococcum* four to twelve bivalents were found [Kostoff, 1935]. The extra five bivalents besides the normal seven are due probably to pairing between chromosomes of *vulgare*. The formation of numerous extra bivalents in *T. vulgare* × *T. monococcum* together with the rare occurrence of multiple configurations in *T. durum* × *T. monococcum* evidently shows that there are interchanges of chromosome segments between chromosomes of the same or of different genomes.

Contrary to the above findings, some previous investigators found no multiple configurations in *T. turgidum* × *T. vulgare* [Watkins, 1924], *T. sphaerococcum* × *T. turgidum* [Vakar, 1932] and *T. turgidum* × *T. durum* [Hosono, 1935]. The occurrence of multiple configurations in *T. vulgare* × B. W., *T. sphaerococcum* × B. W., *T. durum* × B. W., and *T. turgidum* × B. W. shows that the external interchanges of the chromosomes of 'blue' wheat are long enough for autosyndesis to take place.

The percentage of ring is much higher in *T. durum* × B. W. than th obtained in tomato [Upcott, 1935]. In all the hybrids, the multiple cor gurations are almost exclusively rings and chains. Interstitial chiasmata formed only between homologous members (Figs. 2, 3 and 5). Multi configurations other than ring or chain require more than one chiasma on t same arm [Upcott, 1935], the failure of the latter indicates that the extern interchanges between non-homologous chromosomes form terminal chiasma only [Upcott, 1937, 2] and thus the duplications are not long enough for t chiasmata to be formed.

Morphologically the multiple configuration in *T. turgidum* × B. W. similar to one of the two in *T. durum* × B. W. (Figs. 7 and 8). The consta similarity in the morphology of the multiple configurations of both hybr suggests that the two sets of four chromosomes may be the same. If this the case, then *T. durum* has two more common segments on those fo chromosomes which form another association of four (Fig. 2) with 'blu wheat than *T. turgidum* with 'blue' wheat.

The frequent failure of the association of four chromosomes in *T. turgid* × B. W. is due probably to the lower homology between the non-homolog members, as for the two types of configurations obtained there is only fourth of chance that the fourth one can pair with its homologue.

The above mentioned shows that the homology of the homologous ch mosomes is higher in *T. turgidum* and 'blue' wheat than in *T. durum* 'blue' wheat; the homology between the non-homologous members is invers true for the two hybrids.

In *T. pyramidale* × dwarf hill-wheat, the interchanges are not o short, terminal ones but are limited to two pairs of chromosomes. All other chromosomes show normal pairing, except the inverted regions.

B. Interference of pairing between configurations

Among the 10 cells mentioned in *T. vulgare* × B. W., there are four ca wherein association of more than two chromosomes is correlated with an crease in the number of univalents as well as a decrease in the frequency chiasmata. It seems likely that chiasma formation between more t two chromosomes interferes with the chiasma formation of the other memb It is due probably to interference of pairing during the zygotene st [Darlington, 1937]. This coincides with the finding in *Matthiola incana* Armstrong and Huskins [1934] that the increase of multiple associat resulting from translocations and duplications is correlated with the decre in normal pairing. The frequencies of the multiple configurations, the valents and the chiasmata for individual cells are listed in Table VI.

The relation between the multiple configuration and the total chia frequency for every individual cell is detected by computing the coeffic of contingency between the two factors mentioned. The 'C' value and standard error are $0{\cdot}992 \pm 0{\cdot}005$, showing that multiple configurat are negatively correlated with the frequency of chiasmata. The reduc in the chiasma frequency is undoubtedly due to interference in nor pairing which is a consequence of the formation of multiple configuratio

TABLE VI

Distribution of multiple configurations, univalents and chiasmata

Cells	1	2	3	4	5	6	7	8	9	10
tiple config.	1	0	0	1	0	2	1	0	1	1
valents	5	11	7	10	7	10	13	7	12	6
ısmata	36	30	32	26	30	27	25	37	29	32

Ribbands [1937] in *Lilium* × *testaceum* found that there was no relation ween the frequency of univalents and the chiasma frequency of the re- ning bivalents. The writers' results show that the frequency of univalents negatively correlated with the chiasma frequency. The value of 'rank relation' and its standard error amounting to—0·755 ± 0·136 show that frequency of univalents is a net index of the failure of pairing which is a sequence of interference.

Thus the interference caused by the formation of multiple configurations be detected by either the chiasma frequency or by the frequency of the valents. The frequency of univalents is positively correlated with the quency of multiple configurations and the chiasma frequency is negatively related with the latter.

Interference between configurations other than the multiple configurations ther, 1936] cannot be detected because the separate bivalents cannot be inguished.

Structural changes

1. *Inversions*. Bridges of the first division are due to crossing-over in the erted region which results in an acentric fragment and a dicentric chro- id. Bridges in the second division are due to crossing-over in the inversion ch results in a loop and an acentric fragment in the first division and thus lge and fragment in the second division [Darlington, 1937].

(*a*) Number of inversion : The occurrence of two single bridges in one in *T. pyramidale* × B. W. indicates that there are two chromosomes pos- ing inversion. In all the other hybrids except *T. vulgare* × 'blue' at only one chromosome possesses such an inversion.

(*b*) Size of inversion : The size of the acentric fragment equals the sum he length of the inversion and the portion distal to the inversion [Upcott, 7, 2]. The small size of the fragment (Figs. 11, 13 and 14) shows that the of the inversion can hardly be large.

(*c*) Position of inverson : In *T. durum* × B. W. the bridge is quite thick l the arms of the bridge are only a little bit shorter than the thick portion he bridge (Fig. 9). Thus the container of the inversion and its homologue

probably have sub-median centromeres and the inversion is near to the end of the longer arm [Richardson, 1936 ; Upcott, 1937, 2]. This is supported by the small size of the fragment. The chromosomes involved in *T. durum* × B. W. and *T. vulgare* × B. W. are probably similar members (Figs. 9 and 13). Another bridge (Fig. 12) from a different cell of *T. vulgare* × B. W. shows a different morphology. The chromosomes probably have median centromeres. If this is so, then *T. vulgare* × B. W. is heterozygous for at least two inversions. In *T. sphaerococcum* × B. W. the inverted segment is near to the end of the longer arm of the chromosomes possessing subterminal centromeres (Fig. 14). It seems likely that the container of the inversion and its homologue are a different pair of chromosomes in comparison with *T. durum* × B. W. and *T. vulgare* × B. W. The two bridges are due to the two loops and two fragments of the first division resulting from a chiasma proximal to the inversion, which is disparate with respect to complementary chiasmata in the inversion.

In *T. pyramidale* × dwarf hill-wheat the inverted segment is on the shorter arm, because the bridge is thin and the arms are, on the contrary long and thick (Fig. 10) [Richardson, 1936]. The other chromosome pos sessing an inversion has sub-median centromere (Fig. 11).

The striking thing to which attention should be paid is that so far as ou material is concerned no bridge formation occurs in *T. turgidum* × B. W This logically follows that *T. durum* but not *T. turgidum* differs from 'blue wheat by an inversion. Here again, a higher degree of homology is reveale between chromosomes of *T. turgidum* and 'blue' wheat than those of *T durum* and 'blue' wheat.

2. *External interchanges*. The details are mentioned under 'A. Configura tions'.

3. *Undefined structural changes*. The undefined structural changes resu in the reduction of the frequency of chiasmata [Darlington, 1937]. The genera difference of the chromosomes is shown in Tables II to V. The higher degree c homology between the homologous chromosomes of *T. turgidum* and 'blue wheat not only gives 0·45 more bivalents (in comparison with *durum* × B. W but also shows a higher frequency of chiasmata for every individual bivalen every potential bivalent and a higher average total frequency of chiasmata pe cell. In *T. turgidum* × B. W. 76·6 per cent of the total chiasmata is terminal a compared with 90·5 per cent in *T. durum* × B. W., in other words, 23· per cent in the former and 9·5 per cent in the latter are interstitial. Since higher frequency of chiasmata, especially that of interstitial ones, is alwa positively associated with the degree of affinity, therefore, we have anothe evidence that phylogenetically 'blue' wheat is more closely related to *T turgidum* than to *T. durum*.

The frequency of chiasmata in *T. pyramidale* × D. H. W. is nearly high as that in *T. turgidum* × B. W. (Table III). It shows not only a simil distribution, but also a very close mean as compared with that in *T. turgidu* × B. W. A comparison of the bivalents possessing different number chiasmata is shown in Fig. 15, and the distribution of total chiasmata f individual cells is listed in Table VII.

Both the frequency of chiasmata per potential bivalent and that per cell *T. vulgare* × B. W. are similar to those in *T. sphaerococcum* × B. W. ; but

ıe latter the coefficient of terminalization is somewhat lower. The distri-
ıtion of total chiasmata for individual cells of the pentaploid hybrids is
ted in Table VII.

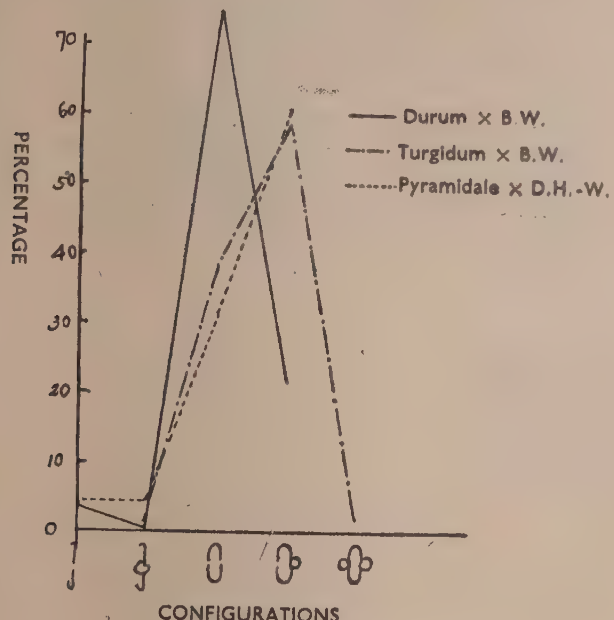


FIG. 15. Showing the comparison of the bivalents possessing different number of chiasmata

TABLE VII

Distribution of total chiasmata for individual cells

Chiasmata	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	No. of cells observed	Mean & S. D. m
ri × B. W.		1		3	4	4	4	2		1	1						20	30·15±0·460
um × B. W.							1	2	3	3		1	2	3		1	16	35·00±0·647
idale × B. W.							2	2			2	1	2	1			10	34·40±0·812
ge × B. W.	1	1	1		1	2		2				1	1				10	30·40±0·194
ococcum × B. W.		1		1		1		2									5	29·60±0·043

Inaphase division

1. *Behaviours of univalents.* The univalents are distributed at random
usually divide in the first and lag in the second division. They form

supernumerary nuclei during the tetrad stage, if they are not included i
daughter nuclei.

In *T. pyramidale* × D. H. W. the univalent laggard may fail to
(Fig. 16) in the first division. There is no doubt of its being a true
valent [Upcott, 1937, 1]. Its failure to divide is due probably to a delay
moving on to the equator [Darlington, 1937].

2. Fragmentation of univalents has been observed in the second ana
of *T. sphaerococcum* × B. W. (Figs. 17, 18 and 19), due probably to the
division of centromeres described by Upcott [1937, 1] and Darlington [
Mis-division takes place in both divisions. A four-to-none type of di
(Fig. 19) has been observed. They more frequently show normal division
first anaphase and mis-divide in the second anaphase (Figs. 19 and 21)
mis-division of the centromere is due to the double structure of the
[Darlington, 1939, 1940].

FIG. 16. Failure of division of a univalent lagged in anaphase I of *T. pyramidale* × 'blue' wheat

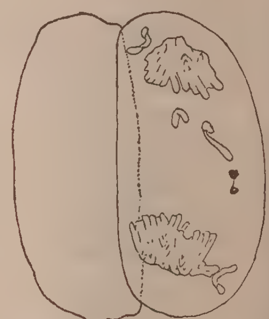


FIG. 17. Mis-division of a univalent second division of *T. sphaerococcu* × 'blue' wheat

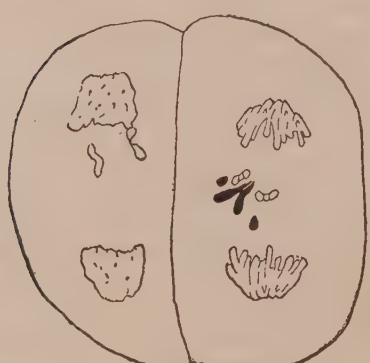


FIG. 18. Mis-division of univalent. A 4-0 type of division takes place in the first division leaving two centric and two acentric arms. Besides, there is, probably, a free centromere

FIG. 19. A univalent mis-dividir the second division

on-disjunction of bivalents

2. Non-disjunction of bivalents has frequently been observed in *T. durum* : B.W. (Fig. 20). This is due to the presence of the interstitial chiasmata stal to which there is probably a change of homology which makes complete rminalization impossible. This is similar to the finding of Darlington 931,2] in *Oenothera* and that of Philp and Huskins [1931] in *Matthiola*.

ormation of unbalanced gametes

During the second metaphase of *T. pyramidale* × B. W. a plate showing = 16 has been observed (Fig. 21). This is due, most probably, to non-sjunction of a multiple association of which the centromeres lie indifferently ith one another.

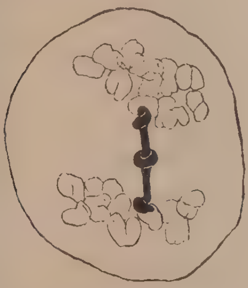


FIG. 20. Non-disjoined bivalent in *T. durum* × 'blue' wheat

FIG. 21. Metaphase II in *T. pyramidale* × D. H. W., showing $n = 16$

SUMMARY

Judging from the multiple configurations, the occurrence of inversions and comparison of the general frequency of chiasmata as well as the average nber of bivalents, 'blue' wheat is phylogenetically nearer to *T. turgidum* ln to *T. durum*.

The occurrence of only one association of four and the high frequency of iasmata together with the absence of wax as well as the dwarf height of the nt which rarely exceeds 3 ft. reveal that dwarf hill-wheat might be ited to *T. pyramidale*.

The pentaploid hybrids between *T. vulgare*, *T. sphaerococcum* and ue' wheat show two multiple configurations. The numbers of univalents 8·8 for *T. vulgare* × B. W. and 8·4 for *T. sphaerococcum* × B. W.

Bridges are observed in all the hybrids except *T. turgidum* × 'blue' wheat.

The formation of multiple configuration is correlated with the decrease in rmal pairing in *T. vulgare* × 'blue' wheat.

Non-disjunction of bivalent and formation of unbalanced gametes are served in the tetraploid hybrids.

Fragmentation of univalents is observed in *T. sphaerococcum* × 'blue' at.

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[S]TUDIES IN THE PERIODIC PARTIAL FAILURES OF THE PUNJAB-AMERICAN COTTONS IN THE PUNJAB

AMELIORATION OF *TIRAK* ON SOILS WITH SALINE SUBSOILS (SANDY LOAMS)

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(With Plates XXVII and XXVIII)

[I]n one of the previous contributions [Dastur, 1941] the ameliorative [effec]t on the opening and yields of the application of the sulphate of [ammo]nia to cotton plants that developed *tirak* on account of a deficiency of [nitrog]en on light sandy soils was described. When the sulphate of ammonia [was a]pplied to such light sandy soils the premature yellowing and shedding of [lea]ves did not occur in the crop, the opening of bolls improved and the [yield o]f *kapas* was greatly increased. A rapid method of spotting the de[ficienc]y of nitrogen in the crop called the 'tannin test' was also dealt with. [It wa]s equally important to develop remedial measures for amelioration of [tirak o]n soils with saline subsoil and intensive studies were undertaken on this [aspe]ct of the problem.

[It] has already been pointed out [Dastur and Sucha Singh, 1942] that the [type] of 'physiological disorder' that sets in plants growing on saline subsoils [is d]ifferent from that which occurs in plants on light sandy soils. In the [latter c]ase the remedial measure for such soils was simple after such soils were [found]. In the case of soils which have high salinity in the subsoil, the [proble]m of removing or counteracting salinity at a depth of 3-4 ft. [is rat]her difficult and complicated. The probable remedial measures for [saline s]ubsoils can be classified into three groups; (1) There are 'known' [metho]ds which would counteract the toxic effects of sodium salts. Under [this ca]tegory may be mentioned the application of gypsum or any other [calciu]m salt which would antagonize the toxic effects of free soluble sodium [salts an]d which by a process of base exchange may replace the exchangeable [sodiu]m with calcium in the clay complex. The toxicity of sodium salts is [known] to depend on the physical texture of the soil. Higher percentages of

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clay or presence of organic matter in the soil may detoxicate the sodium Application of organic manure like the farmyard manure or the green m like berseem or additions of silt (a substitute for clay) were. ther regarded as possible remedies. The use of inorganic fertilizers like nit superphosphates and potash was also considered as they might not be able to the plants from such soils. (2) Salinity in the subsoil may be w down from the feeding zones of the roots by flooding such fields. Flo may be combined with application of gypsum. (3) Measures by whic occurrence of water deficit in the cotton plants at the reproductive stag be either removed or avoided. This group would naturally include the applications of water to increase the amount of available water by keepi non-saline upper surface moist and the reduction of the total leaf area plants by cutting down their vegetative growth.

The applications of these remedial measures become specially di on account of great heterogeneity that is prevalent in the Punjab soils. intermingling of normal soils, saline soils and light sandy soils in the field, presents difficulties for applications of substances to counteract the effect of sodium salts or of washing them down to lower layers by flo Salinity occurs in such an irregular manner that such measures would h be applied even where they were not required. As for instance floodin wash down the salts from the feeding zones of the roots in those part field where salinity is present in the subsoil but it would also leach the important nutrients from normal non-saline areas, specially from the sandy portions, and render them infertile. It is, therefore, necessary th treatment that is either applied to the soil to counteract or to remove s in the subsoil must be such as to ameliorate the soil conditions in the areas while it does not at the same time in any way adversely affect the soil conditions or the growth of plants in non-saline parts. If this p not borne in mind the removal of one evil may be accompanied by the cr in of another.

Another difficulty is that the treatments for counteracting the toxi of salinity must penetrate to a depth of 3 ft. or more in order to effective. That would render their use impracticable as well as unecon

Investigation

The occurrence of *tirak* was noticed in the cotton season of 1 a field at the Lyallpur Agricultural Farm. The soil conditions a behaviour of the plants growing on this field were studied, side by side positions of the normal and *tirak* patches were carefully marked and t conditions under normal and *tirak* crop were investigated. It was esta that *tirak* had developed in regions where the subsoils were saline the subsoils under normal crop were non-saline. This field me 138 ft. × 288 ft. was, therefore, particularly selected for the trial remedial measures of the type discussed above, in the cotton season of 1

The ameliorative treatments were: (1) flooding, (2) gypsum + fl (3) inorganic fertilizers (sulphate of ammonia + superphosphate flooding, (4) gypsum + flooding + inorganic fertilizers and (5) fa manure followed by flooding. The sixth treatment was control.

With the exception of inorganic fertilizers, the other applications were far in advance of sowings. Gypsum was added in two doses of 500 lb. per acre in December, 1937 and January, 1938 followed by flooding time. Flooding was also started from December. Each time the land in *wattar* it was ploughed up. Flooding was done three times before ring for sowing was given. Farmyard manure was applied at the rate tons per acre. The sulphate of ammonia was applied at the rate of . N per acre and the superphosphate at the rate of 150 lb. P_2O_5 before ng. Thus an attempt was made to include all the remedial measures of the two categories.

The remedial measure of the third category was also tried. The idea to cut down the leaf area by reducing the vegetative growth and the natural way to accomplish this was to defer sowings by one month as ared with the normal sowings. As a preliminary trial the inclusion of sowing dates as treatments was, therefore, considered desirable. The field divided into four blocks. Each block consisted of two main plots for wo sowing date treatments. The main plots were subdivided into six plots to which were assigned at random the six treatments enumerated . It was, therefore, a split plot design with eight main plots consisting sub-plots of 1/80 acre each.

Thus it would be normally expected that the most precise information e obtained on the six sub-plot treatments while the information that d be obtained on sowing dates will be less precise as they were allocated main plots. Unsown interstrips were kept in between sub-plots to shading and seepage effects.

owings were done on 5 and 6 May, and 7 and 8 June in the early he late sown plots respectively by dibbling as the small size of the lots did not permit the use of a hand drill. Eight seeds per hole were d at 2¼ ft. × 2¼ ft. distance. Each hole was equidistant from the six nding holes (equilateral system). On account of a heavy shower of n 12 June, received soon after germination, the late sown plots had resown on 15/16 June. Thus the two sowing dates under trial 5/6 May and 15/16 June. The plants were finally thinned to two per hole. The early-sown crop received in all eight waterings, while te sown received six waterings. With the exception of the first two ions to the early-sown crop, subsequent irrigations were given on the day to both the sowings. The last date of watering for both the sowings 8 October.

he crop in each plot was under close observation throughout the season. ing abnormal was noticed in the condition of the plants under each ment uptil September when the May-sown cotton plants began to show ng of leaves. The drooping of the leaves in the May-sown plants d irrespective of the six ameliorative treatments in all plots where the was saline while drooping of leaves was not noticed in any one of the hich were sown in June. Thus one of the symptoms of 'disease' was lly absent in the June sown plots indicating that reduction in leaf evented the development of the water deficit that occurred on such The June sown plants were much smaller in size and consequently ed less foliage than the May-sown crop.

Drooping of leaves was followed by excessive defoliation of the sown plants while shedding was much less in the June-sown crop similar conditions as compared with the early-sown crop at the same st morphological development of the plant. The leaves of the two s presented striking differences in colour and appearance at fruiting. remained green and fresh in the June-sown plants and dull and blackish in the May-sown plants.

At the time of flowering and fruiting the two sowings exhibited important and distinctive features that deserve mention. A delay in sow about 40 days shifted forth the onset of flowering by about 12 days onl flowers were mostly confined to the tips of the branches in the May-sown the lowermost nodes of the main stem did not directly produce the f branches which were located high up on the main stem and the sec branches. In the June-sown plants the sympodia arose directly from th nodes on the main axis and the flowers did not, therefore, appear aggr at the tips as they were widely spaced on them. The growth of the f branches was more vigorous in the late-sown than in the early-sown cr so the successive flowers were separated by longer internodes in the (Plate XXVII, figs. 1 & 2).

The most reliable criterion to judge the quality of opening of th is the weight of seed cotton per boll. The bolls that are badly opene the bolls of *tirak* plants) contain immature seeds and poor lint and, th the weight of seed cotton per boll falls. Contrariwise, the maturity would be reflected in raising the weight of *kapas* of a boll and will be inc of good opening. It was, therefore, undertaken to determine the e different treatments on the weight of seed cotton per boll. Two u five pair of plants each were tagged at random in each sub-plot f purpose. The number of opened bolls from these samples and weight o produced by them were recorded before each picking. The yield experimental area in each sub-plot was then weighed and recorded.

Nodal counts and height measurements of the individual plants for boll weight in each sub-plot were taken when pickings were over. after the number of sticks and their weight were determined plot b These determinations would provide information on the growth made plants under two sowing dates and the six sub-plot treatments. Wit records the weight of seed cotton produced by 100 gm. of stem dry ma be computed to get an idea of the efficiency of the cotton plants for tion of seed cotton under different treatments.

The data collected were subjected to statistical analysis. The ta analyses of variances are given below (Table I). A summarized record s the nature and magnitude of the effect of different treatments is pr in Table II. The differences between the two dates of sowing c highly significant in all determinations despite inadequate replicatio the sub-plot treatments did not differ significantly among themselve interaction of sowing dates with sub-plot treatments was non-signifi dicating no differential behaviour of time of sowing with the s treatments.

FIG. 1. Early-sown (5 May) 4F P.-A. cotton plant (leaves removed) showing that flowers and bolls are borne near the tips of main stem and branches

FIG. 2. Late-sown (16 June) 4F P.-A. cotton plant (leaves removed) showing that flowers and bolls are not aggregated at the top, but are borne at the lower as well as the upper nodes of the branches

FIG. 1. Badly opened bolls with lower leaves shed of the May-sown crop on soils which a
saline in the subsoil

FIG. 2. Well-opened normal bolls of the late-sown crop on soils which are saline in the sub

Analyses of variances

Due to	D.F.	Yield in gm. Mean square	Yield in gm. F	No. of bolls Mean square	No. of bolls F	Weight of seed cotton per boll Mean square	Weight of seed cotton per boll F	Height in cm. Mean square	Height in cm. F	Stem weight per plant gm. Mean square	Stem weight per plant gm. F	Seed cotton per 100 gm. stem weight Mean square	Seed cotton per 100 gm. stem weight F
Blocks	3	8934455·0	24·886**	7676·6	...	0·3787	..	502·1	..	9150·7	..	217·82	..
Dates	1	143036172·6	398·411**	145782·1	148·96**	4·1251	28·119**	8234·1	15·81*	252735·2	53·77**	23306·86	220·16**
Error (*a*)	3	359016·3	..	981·3	..	0·1467	..	520·7	..	4698·9	..	105·43	...
Treatments . . .	5	630280·7	..	774·64	..	0·0194	..	42·1	..	1365·6	..	66·33	..
Dates × Treatments .	5	513032·6	..	1535·60	..	0·0680	..	200·9	..	2803·6	..	61·12	..
Error (*b*)	30	1112926·1	..	2128·99	..	0·1374	..	127·8	..	1261·9	..	29·22	..

*Significant at 5 per cent level of significance
**Significant at 1 per cent level of significance

TABLE II

Treatment effects on the vegetative and the reproductive characters

Experiment I

	Control	Gypsum	Flooding	NP	Gypsum + NP	F. Y. M.	Means for sowing dates	Difference	C. 1 c
				Average yields in lb. per plot					
May-sown (D1) . .	7·5	8·3	9·2	8·2	7·8	7·5	8·1	6·0**	2
June-sown (D2) . .	15·3	14·2	14·7	16·4	15·4	13·6	14·1	...	
Mean . .	11·4	11·2	12·0	12·3	11·6	10·5	...	...	
				Average No. of bolls per hole					
May-sown (D1) . .	25·7	28·9	31·4	25·7	31·2	26·2	28·2	15·6**	
June-sown (D2) . .	42·6	43·5	42·1	47·7	44·0	42·7	43·8	...	
Mean . .	34·2	36·2	36·8	36·7	37·6	34·4	...	...	
				† Sampling error per plot = 10·9 per cent of the mean					
				Average weight of seed cotton per boll in gm.					
May-sown (D1) . . .	1·89	1·95	1·95	1·78	1·86	1·87	1·88	0·42**	
June-sown (D2) . . .	2·35	2·20	2·32	2·42	2·29	2·21	2·30	...	
Mean . .	2·12	2·07	2·13	2·10	2·07	2·04	...	...	
				Sampling error per plot = 5·9 per cent of the mean					
				Average height in cm. per plant					
May-sown (D1) . . .	101·6	109·6	109·4	103·4	100·6	104·8	104·8	18·5*	14
June-sown (D2) . .	85·4	84·3	83·1	89·9	92·3	82·7	86·3	...	
Mean . .	93·5	96·9	96·3	96·6	96·6	96·5	...	...	
				‡Sampling error per plot = 3·4 per cent of the mean					
				Average weight of stem per hole					
May-sown (D1) . . .	283·3	341·5	334·5	353·8	311·0	294·5	319·3	144·7**	1
June-sown (D2) . .	181·3	152·5	162·0	180·0	189·0	173·0	174·6	...	
Mean . .	232·3	247·0	248·0	266·9	255·0	233·8	...	...	
				Average seed cotton per 100 gm. of stems					
May-sown (D1) . .	19	16	19	16	17	19	17·6	42·9**	
June-sown (D2) . .	60	67	64	65	51	56	60·5	...	
Mean . .	39·5	41·5	41·5	40·5	34	37·5	...	...	

*Significant at 5 per cent level of significance
**Significant at 1 per cent level of significance
***C. D. at 5 per cent level of significance
†Sampling errors per plot for various determinations were of an order so as to justify that the samples were fairly representative of the entire plots. The conclusions drawn were, therefore, applicable to the entir
‡Low sampling error for height indicates that this character is less variable than boll number or weight cotton per boll

The performance of deferred sowing was superior to May sowing in of yields, boll numbers and the weight of seed cotton per boll. As al mentioned the late-sown plants did not exhibit the *tirak* symptoms drooping of leaves and their premature shedding. As the opening o bolls in the late-sown crop was significantly superior to opening of bolls i May-sown crop, the maturity of seeds in the bolls in the former case greater than that of the latter. Apparently the mean value 1·88 gn

it of seed cotton per boll is high for a *tirak* crop. But that was due to easons ; firstly, the field was fallow during the previous year and received of preliminary tillage and, secondly, the soil was not uniformly saline in ubsoil over the entire field. Salinity in the subsoil was present in nes only, while non-saline areas were scattered about at random in-een portions having either low salinity or no salinity in the subsoil. The it of seed cotton in the plots where the soil was saline had gone down 0 gm. per boll but that was not the case with the late-sown plants under ir soil conditions. This difference was reflected in the average weight of cotton per boll in the June-sown crop.

Evidently the late sowing had reduced the vegetative growth as the t per plant and stem dry matter per plant were significantly lower in the own plants than those attained by the May-sown.

The late sowing had definitely ameliorated *tirak* and the conception of ing the leaf area of the plant so that water deficit in the crop may not was found to hold good.

The efficiency for production of seed cotton in the late-sown crop appeared significantly higher than that of the early-sown crop. The proportion ed cotton produced per unit dry matter of stems was much higher in ate-sown than in early-sown plants. This is important as what was ired was more of seed cotton rather than of the vegetative growth.

The ameliorative effects of similar treatments for counteracting the rious effects of salinity in the subsoils were again studied in the same n 1939-40 cotton season. Sowing date was omitted from the experiment effect on *tirak* was studied in a separate experiment to be described This experiment was repeated with some changes in the nature of the ments. The plots under flooding in the previous year were treated with silt at the rate of 80 tons per acre. The plots receiving farmyard ire in the previous year were green manured at the rate of 10 tons per acre. reatment gypsum and inorganic fertilizers of 1938-39 was substituted een manuring supplemented by the same inorganic fertilizers, the latter e as a split application in two equal doses (half at sowing and half at ing, total quantities added being the same as in the previous experi-. The remaining three treatments were the same, viz. gypsum, en and phosphorous, and control and they were allotted to the same On account of the omission of sowing dates eight replicates of six nents could then be provided. Thus the layout was a simple rando-d block arrangement.

The drooping of the leaves began to be noticed by the beginning of nber in all plots where the subsoil was saline irrespective of the treat- given. As the season advanced it was evident that the drooping oc-rd on larger areas of the field and was acuter in form in this season than found in 1938-39. The *tirak* had spread to parts of the field which had d in the previous season. The same was the case when the bolls opened. pening was more pronounced and widespread in this season than in the ous one. Thus the *tirak* was more intense than what it was in the us year. This aggravation in *tirak* as already explained in the previous ibution [Dastur and Samant, 1942] was due to a continuous spell y dry and warm weather that prevailed in September and October.

The water deficit in the crop was accentuated by weather conditions
caused *tirak* symptoms to develop on soils which had low salinity in the su
The number of bolls per plant, the weight of seed cotton per bol
yields and the weight of stem dry matter were recorded as before. Stati
analyses revealed the treatment variance to be of the same order as the
variance in case of boll numbers, weight of seed cotton per boll
yields. As the '*z*' test indicated that the treatments were not signi
it was not considered worth while to proceed further with the statistical
The mean values for yields per plot, for the number of bolls per plant a
the weights of seed cotton per boll are given below (Table III). The ge
level of yields was very low because of severe *tirak*.

TABLE III

Treatment effects on yield, boll number and boll weight

Experiment II

	Control	Gypsum	Silt	Green manure	NP	Green manure +NP	Mean
Yields in lb. per plot	2·01	2·92	2·35	1·71	2·55	2·71	2·38
Number of bolls per sq. yd.	40·8	46·5	52·0	38·0	50·6	51·0	46·5
Weight of seed cotton in gm. per boll	0·69	0·87	0·76	0·65	0·83	0·81	0·77

No ameliorative effect of any one of the treatments was found eit
opening of the bolls or the yields as was the case in the previous year.
The magnitude of differences between the yields and weights o
cotton of the May-sown crop in the two seasons 1938-39 and 1939-40
great as can be seen by comparison of Table III with Table II.
A 2^4 factorial experiment was designed in all combin
of $\binom{D_1}{D_2}\binom{S_1}{S_2}\binom{W_1}{W_2}\binom{O}{N}$ where D_1 = crop sown on 14 May, D_2 = crop
on 21 June, S_1 = close spacing 2 ft. $\times$ $1\frac{1}{2}$ ft., S_2 = wide spacing $2\frac{1}{2}$ ft. $\times$
W_1 = normal watering, W_2 = heavy watering in September-Octobe
N = 50 lb. of nitrogen in the form of sulphate of ammonia a
in August. The layout (shown in the Appendix) was a 8×8 quasi
square. All the four second order interactions were partially confo
with the soil differences of columns and the third order interactio
completely confounded with the soil differences of the rows. Thus an at
was made to minimize the effect of soil heterogeneity by eliminating tw
systematic soil variations. The size of each sub-plot was 1/113 ac
sowing.

Observations on the crop under different treatments showed th
drooping of the leaves occurred from middle of September in the May
crop in plots with saline subsoil. This was confirmed by analyses
samples. The drooping symptoms were greatly reduced in such plot
received heavy waterings. No such drooping of leaves was noticed in
which were sown in June (D_2). The drooping of leaves was followed by sh

the first week of October. The bolls in such plots cracked and opened ly.

It may be recalled here that the spread and intensity of *tirak* were also ater in this field in this season of 1939-40 as compared with the previous son, i.e. 1937-38 when cotton was grown in the same field.

In a couple of plots the June-sown crop was as badly opened as the -sown, showing no ameliorative effect of late sowings. Such plots were nd to contain a greater percentage of sand than others in the first 2 ft. he soil and small amounts of alkalinity present within 2 ft. of the face were found to be toxic to the roots. The early and late-sown plots not make normal growth. They were stunted in growth and produced a of badly opened bolls. Except for such plots or portions of such plots -sown crop did not show *tirak*. Statistical analysis has, however, been ied out without rejecting such plots.

The number of bolls per plant and the weight of seed cotton per boll determined from duplicate random samples. Each sampling unit prised of six holes (two plants per hole) in S_1 and three holes in S_2 sub- s. The yield, the height and the weight of stems were taken as before. data for weight of seed per boll, the yields and the dry matter of stems

TABLE IV

Analyses of variances

(2^4 confounded design in 8×8 quasi-Latin square, 1939-40)

Due to	D. F.	Weight of *kapas* per boll		Yield of *kapas*		Dry weight of sticks	
		Mean square	F	Mean square	F	Mean square	F
[illegible]	7	0·1392		26·6547		822·18	
[illegible]ns	7	0·2262		28·3832		2280·62	
[illegible]	1	1·1250	8·66**	2·3831		27121·97	296·17**
[illegible]	1	0·6992	5·38*	191·1652	10·60**	285·19	3·11
[illegible]	1	0·0325		2·7183		8·34	
[illegible]	1	0·2965		191·5802	10·63**	1706·72	18·63**
[illegible]	1	0·5408	4·16*	165·7335	9·193**	365·29	3·99
[illegible]	1	0·0205		10·7339		1·79	
[illegible]	1	0·0914		33·1920		87·19	
[illegible]	1	0·0004		4·0251		21·27	
[illegible]	1	0·0800		5·6228		36·75	
[illegible]	1	0·2945		76·0166	4·22*	57·19	
[illegible]	1	0·0117		0·8374		121·60	
[illegible]	1	0·4320		56·8981		410·67	
[illegible]	1	0·0026		11·0784		24·80	
[illegible]	1	0·3927		8·2751		6·31	
[illegible]	35	0·1299		18·0277		91·57	

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance

were analysed by the method appropriate to the design. The detai analyses of variances are given in Table IV. The significant main e and interactions with respective standard errors are shown in Table V u appropriate subheadings.

TABLE V

Summary tables showing main effects and significant interactions
Experiment III

	Treatment	Average weight of kapas per boll in gm.	Difference with S. E.	Yield in maunds per acre	Difference with S. E.	Weight of stalks in maunds per acre	Differe with S
Main effects	D_2	1·47	** [illegible] ± ·064	13·52	[illegible] ± 1·06	22·92	** −41·17
	D_1	1·2[illegible]		13·46		64·09	
	W_2	[illegible]	* 0·14 ± ·064	15·[illegible]	** 3·40 ± 1·06	45·52	4·22
	W_1	[illegible]		11·5[illegible]		41·4	
	N	1·[illegible]	−0·[illegible] ± ·064	13·41	−0·17 ± 1·06	43·15	−0·72
	O	[illegible]		13·52		43·87	
	S_2	1·4[illegible]	[illegible] ± ·064	15·35	** 3·46 ± 1·06	48·67	** 10·33
	S_1	1·3[illegible]		11·8[illegible]		38·34	

		D_2	D_1	Difference (±0·091)		D_2	D_1	Difference (±1·50)		D_1	D_2	Dif (±
D. W interaction	W_2	1·42	1·48	0·06	W_2	14·77	16·94	−2·33	W_2	65·6	22·65	—
	W_1	1·15	1·46	0·31**	W_1	10·09	13·70	−3·61*	W_1	59·6	23·2	—
	Difference	0·27**	·02		Difference	6·68**	0·24		Difference	9·0*	—·55	
			±0·091				±1·50				±3·38	

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance

The three treatments which were tried for amelioration of *tirak* v (1) deferred sowings, (2) heavy watering and (3) application of nitrogen. last was included only as a precautionary measure though it has been alr shown that deficiency of nitrogen is not the cause of bad opening on soils. A study of Table V will show that both the ameliorative mea deferred sowings and heavy waterings, significantly increased the weig seed cotton per boll indicating better opening of bolls, i.e. less of The interaction of sowing-dates with waterings (D.W) was significant sho that opening of bolls in May-sown crop was greatly improved by heavy wat while the late-sown crop showed no further improvement in opening by application of water, as the improvement in opening obtained by def sowings was of a high magnitude. The plants under late sowings did no require extra water as no disturbance in the water balance occurred in late-sown crop. This was indicated by absence of drooping of leaves in late-sowing. Nitrogen, as expected, had no effect on the weight of seed c per boll. Thus the two remedial measures late sowing and heavy wat at the fruiting stage proved effective in improving opening of bolls, the fo to a greater extent than the latter.

he generalized effect of watering on yields was significant at 1 per cent of significance and the interaction sowing date × watering was also ficant. The early-sown crop profited considerably by extra applica- of water while no benefit accrued to the late-sown. The increase in due to heavy watering in the former was 6·6 md. per acre while the ase was practically nil in the latter. Thus extra watering had helped arly-sown crop in increasing both the yields and the weight of cotton oll while no similar advantage from heavy watering was derived by the own in any case.

he generalized effect of spacing on yields was positive and significant ting that the yield under close spacing was higher than that under spacing. Though the interaction of dates and spacing (D. S) did not out significant, the following data (Table VIa) would show that the own crop benefited more by close spacing than the early-sown. The effect of spacing derives its significance from the significant effect of close ng in D_2 only, the effect of close spacing under D_1 alone being non- icant.

TABLE VI

ction of sowing date with spacing on yield and the effect of sowing dates on waterings on the efficiency of the plant

(a) Average yield in maunds per acre			(b) Seed cotton per 100 gm. of stem weight (efficiency)			Mean
	D1	D2		D1	D2	
. . . .	14·44	16·27	W1	17·21	60·9	39·05
. . . .	12·42	11·36	W2	25·24	64·59	44·92
. . .	+2·02	+4·91**	Mean	21·23	62·74	

** Significant at 1 per cent level of significance

s the early-sown plants were benefited more by watering than the late- plants and as wide spacing had acted against the late sowings, the alized response to sowing dates was small and non-significant. As the ction of sowing dates and watering was significant, no importance hes to the generalized effects as such.

he interaction of spacing with nitrogen on yield was found to be signi- . This was due to an anomalous decrease under wide spacing in the nce of nitrogen. It is possible that some of the plots with wide spacing itrogen came on soils which had high salinity in the subsoil.

he effects of sowing date on growth characters confirmed the conclusion dy reached that late-sown plants remain stunted and produce compara- less dry matter. Heavy waterings increased the weight of sticks cantly on early-sown only, thus bringing out a significant interaction en sowing date and watering.

The efficiency of plants for production of seed cotton was worked out this experiment also. The effect of heavy watering and late sowing on proportion of seed cotton produced per 100 gm. of stem dry matter is given Table VI (b). Obviously the late sowing influences the efficiency of plant seed cotton production. Watering is also effective but cannot comp with late sowing in this respect.

The ameliorative effects of deferred sowings on *tirak* occurring in s with saline subsoil was further determined in another experiment arran at the Risalewala Seed Farm, Lyallpur in the cotton season of 1940-41. experiments discussed in the foregoing pages were conducted with 4F Punj American cotton variety only. It was, therefore, necessary to extend studies by introducing in such experiments a number of *desi* and Ameri varieties. Such a study would disclose not only the relative resistance different American strains to *tirak*, if any, but also their suitability adoption for late sowing.

Accordingly 18 varieties, 15 Americans and three *desis* were included the experiment. Out of the entire lot under trial, there were six commer varieties, four Americans and two *Desis* while the rest were newly evol promising strains which were kindly supplied by the Cotton Resea Botanist, Lyallpur.

The layout conformed to randomized blocks design with sub-plot arran ment. The entire area consisted of six blocks (320 ft. × 119 ft.) of f main plots each (80 ft. × 119 ft.). Four sowing-date treatments were tributed at random to the main plots within each block. Two rows 119 ft. length for each of the 18 strains were accommodated in each m plot. The position of varieties within each plot was perfectly rando Non-experimental belts were cut out on all sides at pickings to avoid bor effect to the main-plot treatments. There was no scope for the provis and subsequent rejection of edge rows to eliminate border effect on varie comparisons. The marked reduction in the standard error of the varie comparison by split plot arrangement, however, dispels the possibility of a considerable border effect influencing the sub-plot treatments. The expe mental sub-plot measured 100 ft. 10 in. × 4 ft. (1/108 acre).

Sowings were done on 8 May, 23 May, 7 June and 23 June in D_1, D_2, D_4 plots respectively. At the time of thinning, the plants were spaced clo and closer as cotton was sown successively later. The spacings adopted the different sowings were : $D_1 = 2$ ft. × 2 ft., $D_2 = 2$ ft. × $1\frac{1}{2}$ ft., $D_3 = 2$ × 1 ft., $D_4 = 2$ ft. × 9 in. The first and the second sowings received all eight and seven waterings respectively while each of the June-sowi was given five irrigations, i.e. three irrigations less than the first sowi Except for such additional earlier irrigations to the May-sown plots, it v so arranged that subsequently all sowings were watered on the same date.

Yield records were maintained throughout the picking season. *D* varieties have to be picked every week and thus it was not convenient record their boll weights in this experiment. Boll weight determinatio from sampled plants were, therefore, confined to 15 American varieties of ea sowing.

A study of analyses of variances (Table VII) revealed that there were ficant variations among the four sowing dates in case of yield as well as nt of *kapas* per boll. The varietal comparisons were also highly signi- on both of them. The interaction 'dates varieties' attained signi- e in yield only.

TABLE VII

Analyses of variances (sub-plot basis)

(Varietal and sowing-date experiment at Risalewala Seed Farm 1940-41)

ue to	Boll weight			Yield of *kapas*		
	D. F.	Mean square	F	D. F.	Mean square	F
. . .	5	2·3096	3·396*	5	48·5325	2·419
. . .	3	12·60266	18·531**	3	116·2191	5·791**
a) .	15	0·6801	..	15	20·0695	
lots .	..	..	..	23		
s .	14	1·1544	13·346**	17	140·4478	70·2239**
. .	42	0·0876		51	5·7876	2·573**
) .	280	0·0865		340	2·2490	
Components of the sum of squares due to dates of sowing						
vs. D_3+	1	27·1590	39·934**	1	135·2625	6·74*
vs. D_1+	1	8·1421	11·972**	1	203·7615	10·153**
vs. D_2+	1	2·5067		1	9·6332	

gnificant at 5 per cent level of significance

Significant at 1 per cent level of significance

e total sum of squares attributable to the three degrees of freedom for ing dates was further split up by regarding them as quality treatments contributions of orthogonal components were tested against the error (a). The last two sowings were found to differ from the first two ntly and the differences were relatively much more pronounced on than on yield. The behaviour of the central sowings was also signi- different from the two extreme sowings. It is, therefore, necessary ed to the detailed Table VIII to grasp the nature and magnitude of ts of the variables under study.

There was a progressive rise in the weight of *kapas* per boll wit delay in sowing upto the third sowing beyond which there was little e Thus a well marked optimum towards the June sowings was clearly br out with respect to the opening of bolls. The magnitude of increas sufficiently high. The sowing dates stood in the order D_3, D_4, D_2, D_1 acco to merit and this order remained virtually the same in the different va taken individually. This accounted for the non-significant intera between the two factors. Improvement in opening in all the varieties brought about to the same extent by delay in sowing. The mean boll we of the varieties showed significant variation among themselves. indicates inherent varietal differences in boll sizes of the different st Boll weight is a composite measure of the all-round development of see lint of a given variety but higher boll weights in certain varieties in parison to others, do not necessarily imply a corresponding reduction i percentage immaturity of seeds. Varieties having large and fuzzy may suffer to the same extent by *tirak* and yet may possess markedly h seed weights due to more of non-essential parts, as compared with non- strains under similar soil conditions.

TABLE VIII

Results of the experiment at Risalewala Seed Farm, 1940-41

—	Average weight of *kapas* per boll					Mean yield in lb. per sub-plot (1/108)			
	D_1	D_2	D_3	D_4	Mean $\pm 0 \cdot 06$	D_1	D_2	D_3	D_4
LSS . . .	1·37	1·56	2·11	2·08	1·78	3·63	5·08	6·66	6·80
4F . . .	1·16	1·44	1·80	1·47	1·49	2·91	4·38	7·25	4·34
289F/43 . .	1·19	1·74	2·18	1·68	1·70	2·98	4·20	5·11	4·61
289F/K25 . .	1·30	2·00	2·22	2·00	1·88	3·97	5·78	5·23	4·32
LSS early . .	1·55	1·84	2·32	2·22	1·98	4·64	9·63	11·27	9·70
289F/124 . .	1·42	1·84	2·28	2·26	1·95	5·26	6·98	7·22	6·77
289F/126 . .	1·70	2·03	2·72	2·48	2·23	5·07	6·50	8·14	7·05
289F/127 . .	1·43	1·90	2·17	2·26	1·94	4·95	6·65	4·16	4·38
289F/144 . .	1·40	1·94	2·19	2·08	1·90	4·77	5·90	6·67	5·26
289F/155 . .	0·86	1·40	1·60	1·64	1·37	2·37	4·91	4·84	4·26
289F/156 . .	1·21	1·86	2·37	2·12	1·89	4·66	7·61	8·40	6·06
289F/157 . .	1·24	1·73	2·14	1·98	1·77	5·41	6·90	6·45	5·53
289F/158 . .	1·36	1·87	2·35	2·30	1·97	4·23	7·21	7·33	6·40
289F/159 . .	1·38	2·14	2·03	2·08	1·91	5·57	8·26	6·26	5·47
289F/186 . .	1·12	1·41	1·87	1·79	1·55	3·45	4·77	6·22	5·69
DC17 . . .						10·0	8·92	11·71	10·22
Mol 39 . .						12·09	10·74	15·14	13·32
Sang 119 . .						9·24	11·01	12·03	10·58
Mean .	1·31	1·78	2·16	2·03		5·20	6·96	7·78	6·71
	$\underbrace{\qquad\qquad}_{\pm \cdot 087}$					$\underbrace{\qquad\qquad}_{\pm \cdot 431}$			
S. E. of the body of the table (interactions and varietal effects only)					$\pm 0 \cdot 12$	$\pm 0 \cdot 612$			

The optimal value for yields was obtained in the third sowing after ich there was a tendency for falling off in the effectiveness of further delay sowing. This was attributable to a dimunition in the boll number per t area caused by a reduction in growth and also by some jassid attack in the sowing in the susceptible varieties. Even then the mean yields of the rth sowing were higher than those of the first sowing and compared favour-y with those obtained from the second sowing. The varieties susceptible jassids attained an earlier optimum in relation to sowing date than others stant to them. This explains partly the significant interaction.

Conclusions

The results discussed above clearly indicate that *tirak* occurring on soils ch have a saline subsoil can be ameliorated by either reducing the water uirements of the crop by means of deferred sowings or by applications of a water from the beginning of the flowering phase so that upper non-ne layers may adequately meet the demand of the crop. The first re-ly of deferred sowings is to be preferred to the second as the former enables crop to meet its own demands for water without external aid. The ner is also a more practical remedy than the latter as the water supply is ally limited. There is considerable observational and experimental lence to support the view that the late sown crop is better adapted to its phic and climatic environment than the early-sown (May-sown) crop. late-sown crop shows no symptoms of water starvation and consequently ble to mature its crop of bolls under saline conditions of the soil or un-urable conditions of weather or both. A late-sown plant is thus in phy-ogical equilibrium with its environment and is able to stand the vagaries veather which many a time is dry and warm during the fruiting period. also a more efficient organism than a May-sown plant. It produces e of seed cotton in proportion to its size than what an early-sown plant s. The latter exhausts itself in the vegetative growth and by the time s are formed, it has already reached a stage of senescence. A slightly ner temperature than normal for a brief spell of three weeks or so is suffi-t to upset its metabolic processes on such saline subsoils, for the plant lost its capacity for adjusting itself to such changes in its environment. particular advantage is also gained by the sowing of the cotton crop in May n on non-saline soils as the crop exhibits a kind of photoperiodism. The ering phase does not set in early in an early-sown and if it does, such ers do not develop into bolls and are generally shed. The onset of ering is not proportionately delayed as the sowings are delayed ; a shift he date of sowing does not materially influence the main flowering od which occurs in the month of September. Early sowings will be antageous only when the flowering period is also considerably prolonged. A flowering period would enable the crop to mature a larger number of bolls what they do. But as the matters stand the early-sown crop becomes un-anced with a long vegetative phase and a short reproductive phase. This of balance between the two phases results in a low efficiency in production eed cotton.

The June-sown crop, however, suffers from a disadvantage as compar with the early-sown crop. As the vegetative phase is shortened t bearing points are reduced resulting in a reduced number of bolls. But t disadvantage can be counteracted by closer spacing of plants, i.e. by increasi the number of plants per acre. This measure will make up for the decrease bearing on the late-sown plant and the crop will at the same time be less su ceptible to *tirak* on saline subsoils and will produce better quality of lint.

A large number of experiments laid out on zemindars' fields have su stantiated the conclusions discussed above and these results will be discuss in another contribution.

The ameliorative measures for counteracting the toxic effects of salini in the subsoil such as the use of gypsum, silt and green manuring have n proved effective and *tirak* occurred irrespective of these treatments. The measures would also be beyond the means of zemindars, even if they we successful. There would also be difficulties of their application to the rig place as *tirak* also occurs on soils which are not saline in the subsoil [Dast and Samant, 1942].

The attempt to leach down the salts by flooding to deeper layers of s has also not proved successful. Applications of nitrogenous fertilizers a superphosphates produced no ameliorative effect on *tirak* on such soils.

SUMMARY

Tirak or bad opening of bolls in the Punjab-American cottons on so with saline subsoils is mainly caused by a disturbance in the water balar of the plant. A water deficit arises in the plants towards the fruiting sta which is the most critical period of plants' life and becomes more and m pronounced with the march of time. Salinity in the subsoil renders t absorption of water difficult and the plants succumb to the physiologi drought. Three types of ameliorative measures were tried for counteracti toxic effect of salinity: (1) applications of gypsum, silt, farmy manure and green manures, (2) washing down of the salts from the feedi zones of the roots by flooding of such lands and (3) efforts for preventing t development of a water deficit by means of cutting down the vegetati growth (e.g. by late sowings) or by giving extra applications of water at t fruiting stage.

Replicated field experiments were conducted to study the effects of the three types of ameliorative measures during the cotton seasons of 1938-3 1939-40 and 1940-41 on such lands where subsoil salinity was known to ex and where *tirak* had previously occurred.

Of the three types of ameliorative measures, the two measures of t third group, viz. deferred sowings (June sowings) and extra applications water from the flowering stage proved successful in remedying *tirak* while the measures of the first two types failed to produce any effect.

Deferred sowings did not show drooping of leaves in October as was t case with the May-sown crop on such soils. There was also no prematu defoliation. The opening of bolls (weight of seed cotton per boll) and t yields were significantly, better in the June-sown crop than those of the M sown crop. Similarly, heavy watering from fruiting stage lessened *ti*

ciably and increased the yields in comparison to normal waterings. y watering had no effect on the opening or the yield of June-sown crop latter did not stand in need of extra water and was not profited by it. sowing was found to be superior to heavy watering in effect on *tirak*.

une sowings produced less number of bolls per plant than May sowings count of a reduction in the vegetative growth in the former. This was a vantage in late sowings but it was successfully counteracted by increasing umber of plants per acre. This could be done by adopting closer ng of plants.

he experiment laid out in 1940-41 was a varietal-cum-sowing-date trial. were four sowing dates equally spaced at fortnightly intervals com- ng from the second week of May with 15 American varieties and three arieties.

he results of boll size (weight of seed cotton per boll) showed that ng of bolls improved as the sowings were delayed. The opening of n the two June sowings was significantly better than that of the May gs. The improvement in opening was universal to all the varieties ed for study. Similarly, the mean yields of the former were signi- y higher than those of the latter. Varieties differed in their adapt- to late sowing. The strains resistant to jassids were in general suited to the June sowing while those susceptible to them had a well d optimum towards the central sowings (end of May to second week ne). The first sowing gave lower yields under all varieties taken dually.

ne crop when sown in June is in a physiological equilibrium with its nment on soils with saline subsoil. It does not suffer from water star- on such soils while the May-sown crop does. The production of seed in proportion to plant size (dry weight) is much higher in late-sown as red with that of the early-sown. The disadvantage of reduction in g which usually accompanies this practice can be counteracted by ing the number of plants per acre by reducing the distance between rs and adopting closer spacing from plant to plant within the rows.

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APPENDIX

Layout plan with treatments and yields in maunds per acre of the 2^4 factorial design on 4-F cotton in sq. 27 D_1, 1939-40 (8×8 quasi-Latin square)

Column No. 1 .	D1 W1 S1 8·15	D1 W1 S2 9·88	D2 NW1 S2 13·84	D2 NW1 S1 25·89	D1 NW2 S1 12·81	D1 NW2 S2 20·58	D2 W2 S2 15·19	D2 W2 S1 21·01
Column No. 2 .	D1 NW2 S1 21·63	D2 W1 S1 17·22	D2 NW2 S1 17·72	D1 W1 S1 15·04	D1 NW1 S2 7·57	D2 W2 S2 10·71	D2 NW1 S2 14·86	D1 W2 S2 21·22
Column No. 3 .	D1 W2 S2 20·99	D2 NW1 S2 10·73	D1 W1 S2 12·69	D2 NW2 S2 10·16	D2 W2 S1 15·23	D1 NW1 S1 9·57	D2 W1 S1 14·76	D1 NW2 S1 17·66
Column No. 4 .	D1 NW1 S2 8·52	D1 NW2 S2 13·62	D2 W2 S2 10·25	D2 W1 S2 10·98	D1 W1 S1 22·66	D2 NW2 S1 12·79	D1 W2 S1 12·24	D2 NW1 S1 18·54
Column No.5 .	D2 W1 S2 11·59	D1 NW1 S1 3·23	D2 W1 S1 10·03	D1 NW1 S2 6·77	D1 W2 S2 17·70	D1 W2 S1 10·78	D2 NW2 S1 18·14	D2 NW2 S2 9·86
Column No. 6 .	D2 W2 S1 16·34	D2 NW2 S1 13·89	D1 NW2 S2 6·30	D1 W2 S2 20·14	D2 W1 S2 11·44	D2 NW1 S2 5·01	D1 NW1 S1 6·01	D1 W1 S1 7·21
Column No. 7 .	D2 NW2 S2 10·24	D2 W2 S2 11·18	D1 W2 S1 14·99	D1 NW2 S1 28·37	D2 NW1 S1 16·45	D2 W1 S1 10·89	D1 W1 S2 8·08	D1 NW1 S2 7·45
Column No. 8 .	D2 NW1 S1 14·40	D1 W2 S1 17·50	D1 NW1 S1 23·19	D2 W2 S1 17·46	D2 NW2 S2 12·79	D1 W1 S2 5·96	D1 NW2 S2 11·75	D2 W1 S2 13·52

COVERY OF WHITE SUGAR FROM THE PUNJAB AND THE UNITED PROVINCES CANES

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THE investigation described in this paper was carried out during the two cane seasons 1937-38 and 1938-1939, in order to throw light on the ed differences in the percentage recovery of sugar from canes imported the Punjab from the United Provinces for the then existing Sonepat r Factory and the corresponding canes grown locally. The Punjab Sugar oration reported that the recovery for local Sonepat canes was 7·7 per as against 10·18 per cent for corresponding canes imported from Amroha elsewhere in the United Provinces. A systematic analytical survey of the s grown in the two provinces, combined with investigations of the soils on h the canes were actually grown, was accordingly carried out in order to v light on the differences in percentage recovery recorded. The canes in articular areas in the Punjab and the United Provinces in which this in-gation was carried out in 1937-38 unfortunately experienced an excep-lly bad attack of pyrilla, which to a considerable degree rendered the ts less conclusive than was desired. Valuable data were, however, collect-ring the first year's survey but owing to the abnormal conditions it was ted in the following year, i.e. 1938-39, as it is obvious that in order to n reliable comparative data on such a matter as this the data must be ted during a season when normal conditions prevail. It is, however, st impossible to find any extensive area during any season, where what t be called 'absolutely normal conditions' do prevail. For example g the second year of the investigation although pyrilla was practically t, the canes in both the provinces were subjected to drought of greater sity than during the first year.

The United Provinces grow more than half the total cane produced in , the chief tracts being the Meerut, the Rohilkhand division in the west, the Gorakhpur division in the extreme east.

For the investigation under report eight localities were selected, four from estern United Provinces, namely Meerut, Bisokhar, Salimpur and Amroha, four from the south-eastern Punjab, namely Karnal, Tharu, Rohat and uhli. In the 1938-39 survey, the districts in the Punjab were the same but United Provinces, Billari village in the Moradabad district and Shah-pur were added and Bisokhar omitted.

Owing to the above-mentioned attack of pyrilla and the removal of Sonepat Sugar Factory to Amroha there were only 2,895 acres under

sugarcane in the 1938-39 season in the Sonepat tehsil, as against 11,557 i 1937-38 season. Also, very little of this cane of the second year was for the manufacture of *gur* or sugar but was chiefly employed as fodde account of famine. Similar conditions prevailed in the United Provi where a number of factories did not work for more than two months.

Climate

The western part of the United Provinces receives a higher rainfall the south-eastern Punjab, the monsoon usually setting in about the mid June from which date monsoon conditions prevail until about the en September. Furthermore, the eastern portion of the area in the U. P. u report usually gets a considerably higher rainfall than the western par shown from the data in Table I. The rainfall, however, during the mon prior to the first year's investigation was below normal in all the loca investigated and this factor occurring at a period when the cane is at a of maximum growth caused the crop to be stunted both in the United Prov and the Punjab. This undoubtedly constituted one of the predisposing c to the severe attack of pyrilla during the ensuing cane season, during w there were occasional frosts which, however, were not severe enough to d harm. The major trouble was pyrilla.

Table I

Rainfall in inches during the last five years at the localities under surv

Locality	Years					Av
	1934	1935	1936	1937	1938	
Meerut (Western United Provinces)	30·25	21·52	23·46	17·88	9·79	
Muzaffarnagar (for Salimpur) (Eastern United Provinces.)	36·24	31·43	41·58	32·51	26·32	
Amroha (Eastern United Provinces)	22·99	39·39	50·93	26·99	31·95	
Shahjahanpur (Eastern United Provinces)	38·04	25·75	70·23	22·78	39·43	
Sonepat (South-eastern Punjab)	17·35	17·25	23·85	19·92	9·32	
Karnal (South-eastern Punjab.)	31·74	43·15	34·26	25·09	18·60	

We have already mentioned how the trouble from pyrilla was reflec a certain extent in a smaller acreage under cane in 1938-39 than in 1937-3 how difficult it is to find, what may be called, a normal season. In th year the rainfall in the previous monsoon was below normal and was con with an attack of pyrilla and in the second year although there was fr from pyrilla yet the rainfall in the previous monsoon was lower than first year both in the Punjab and the United Provinces, particularly at M and Sonepat. As a result of this deficient rainfall during the period wh

ane crop most needed it, the crop in both the provinces was stunted and onsequently matured earlier. In the 1938-39 cane season, there was no frost nd consequently quality was maintained throughout the short crushing eason.

Soils and general agricultural practices

The nature of the soils from that part of the United Provinces investigated nd of the south-eastern Punjab varies from sandy to medium loams tending) somewhat heavier types in the subsoil. On the whole, however, the analytial data from these soils and agricultural experience show them to be eminently iited, in both provinces, to the production of cane. Average analytical date omputed from separate investigations in a number of localities in both the rovinces are given below :—

Percentage on air-dried soils

Depth	Total nitrogen	Organic matter	Exchangeable calcium	Available P_2O_5	Maximum water-holding capacity	Water-soluble salts	Clay	pH
nited Provinces—								
1st foot .	0·0553	0·650	0·096	0·055	37·3	0·117	13·4	6·58
2nd foot .	0·0448	0·426	0·144	0·042	37·0	0·102	21·2	6·72
3rd foot .	0·0392	0·376	0·187	0·032	38·5	0·090	24·8	6·81
ujab—								
1st foot .	0·0740	0·900	0·158	0·035	40·7	0·200	19·4	6·95
2nd foot .	0·0548	0·706	0·182	0·030	40·6	0·170	25·7	6·78
3rd foot .	0·0496	0·583	0·186	0·031	40·6	0·178	27·6	6·62

An interesting point brought out in the survey was that the soils of the uth-eastern Punjab, are comparatively heavier and contain a greater amount exchangeable calcium than the soils from the western United Provinces here is not much difference in the reaction of the two soils although the United rovinces soils have slightly lower pH values. The differences in the value of e two sets of soils for sugarcane production appear to lie in the differences the amounts of water-soluble salts and exchangeable calcium in the soils of e two provinces. In the Punjab the soils contain a considerable concentraon of water-soluble salts which accumulate near the surface, but in the United ovinces, where rainfall and humidity are both greater and where the soil lighter, the percentage of water-soluble salts is much less. It is perhaps is fact more than any other which may influence the ash content of the garcane juice and subsequent percentage recovery of sugar in the factory, d which may consequently form an explanation of the alleged difference in e value of two sets of canes in sugar production. As shown by Lander and

Ramji Narain [1936], it is the greater amount of ash in the juice from t Punjab canes rather than its slightly lower sucrose content as compared w the juice of the sugarcane from the United Provinces, which is responsible the lower net rendiment value of the *gurs* made from the Punjab canes. Th are certain other factors also which appear to have a definite bearing both the quantitative and qualitative production of cane in the United Provin and the Punjab. The most important of these appear to be climatic in rega to the relative degree of rainfall, and the variations in certain important pects of agricultural procedure. In the United Provinces *barani* land usua produces a moderately good crop of cane which could not be produced corresponding lands in the Punjab. Again, average well-cultivated soils the Punjab usually receive far more natural manure than the average corr ponding United Provinces soils, which accounts for the fact that the forn are generally richer in nitrogen and organic matter than the latter. There exceptions, however, and in some parts of the United Provinces, intens manuring produces soils richer in nitrogen and organic matter than is fou in average Punjab soils. Again, the cost of cultivation owing to gene economic conditions is lower in the United Provinces than in the Punjab, which reason cane is a more extensively grown crop in the former provin Of the total cultivated area in the localities surveyed, about 20 per cen under cane in the United Provinces, against 10 per cent in the Punjab. the other hand, the standard of cultivation and the amount of manure u are, as a rule, higher in the Punjab, so that land irrigated by well or ca water in the Punjab generally produces more cane per acre than correspond land in the United Provinces.

Pests

As already mentioned, the 1937-38 cane crop in both the western Uni Provinces and south-eastern Punjab was severely damaged by pyrilla. high-yielding varieties, such as Co 312, suffered most, and the more luxuri and succulent the leaves the heavier was the attack. The natural result a juice of inferior quality with a diminished sucrose content and so hig glucose content that *gur* could not be prepared from it. As a typical exa the following table shows the deterioration of Co 312 as a result of this att

Co 312 (Karnal) attacked by pyrilla

Date of analysis	Percentage on sugar cane						Pu coe cic
	Juice	Sucrose	Glucose	Total sugars	Tota. solids	Glucose ratio	
9 Dec. 1937	71·8	3·2	1·65	4·9	6·1	51·1	5
27 Dec. 1937	75·6	4·3	2·08	6·4	7·8	48·4	5
12 Jan. 1938	74·9	4·0	1·81	5·8	7·3	45·2	5
24 Jan. 1938	74·6	3·7	1·82	5·5	6·6	49·2	5
8 Feb. 1938	75·2	4·8	1·79	6·6	7·6	37·3	6

)uring the following season the crop was free from pyrilla and the cane ...d normally as shown below :—

Co 312 (Karnal) free from pyrilla (1938-39)

D. e of analysis	Juice	Sucrose	Glucose	Total sugars	Total solids	Glucose ratio	Purity coefficient
D. 1938 .	69·3	9·6	0·73	10·3	11·6	7·6	82·8
D. 1938 .	67·9	8·9	0·29	9·2	10·7	3·0	83·2
J. 1939 .	67·6	11·2	0·26	11·5	12·6	0·9	88·9
J. 1939 .	71·6	11·3	0·10	11·4	12·8	1·2	88·3
F. 1939 .	66·7	10·1	0·14	10·2	12·3	1·4	82·1
F. 1939 .	72·1	11·0	0·14	11·1	12·5	0·8	88·0

PLAN OF WORK DURING THE SURVEYS

n considering the data from different localities surveyed it may be men- ... that all the varieties at each place were analysed six times during each ... from the beginning of December till the first week of March. It is not ...sed to give all the analytical data collected each year, but only the average ...osition of different varieties, together with figures for the glucose ratio, ... coefficient and saline coefficient for the maturity periods. The figures ... yield of stripped cane, total solids and sucrose per acre, have also been ...ed. The soils from the fields from which the canes were analysed were ...ed at a number of places to a depth of 3 ft. and corresponding 1 ft. ...es from all the bores were mixed together, so that three composite samples ...obtained from each locality for analysis.

LOCALITIES SURVEYED

The United Provinces

...ernment Agricultural Farm, Meerut

he soil of this farm is an average loam but becomes somewhat heavier ... the first foot. The average composition of the soils of this farm is ... below :—

Percentage on air-dried soil

...h	Total nitrogen	Organic matter	Water-soluble salts	*p*H	Exchangeable calcium	Available P_2O_5	Clay	Silt	Sand
... ft	0·0680	0·970	0·180	7·81	0·120	0·046	15·1	25·4	59·44
... ot	0·0476	0·421	0·160	8·34	0·136	0·030	24·9	31·4	43·70
... ot	0·0476	0·405	0·180	8·54	0·124	..	27·7	32·8	39·48

...e soil is alkaline in reaction, possesses a moderate amount of exchange- ...lcium and a moderately high percentage of water-soluble salts.

...our varieties of canes were examined, viz. Co 244, Co 312, Co 313 and ...1, the analytical data from which are given in Table II.

TABLE II

Analytical data of the varieties of cane grown at the Government Agricultural Farm, Meerut

(Average during the ripening period)

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 244 : 1937-38	71·7	9·7	0·59	10·5	11·4	0·9	0·409	6·1	83·1	24·0	586·3	56·8	66·8	5/1 to 14/2
1938-39	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Co 312 : 1937-38	72·3	8·8	0·80	9·6	10·8	1·2	0·405	9·1	81·4	22·0	920·6	81·0	99·4	31/1 to 14/2
1938-39	69·2	9·6	0·37	10·0	11·3	1·3	0·399	4·1	85·3	25·7	940·0	90·2	106·2	18/12 to 20/2
Co 313 : 1937-38	68·1	10·1	0·25	10·4	11·4	1·0	0·548	2·4	88·6	18·5	547·9	55·3	62·4	17/1 to 14/2
1938-39	7·2	10·7	0·18	10·9	12·3	1·4	0·482	2·0	86·2	24·1	659·9	70·6	81·2	6/12 to 20/2
Co 331 : 1937-38	69·3	9·0	0·50	9·5	10·8	1·3	0·503	5·5	85·3	18·0	607·1	54·6	65·5	31/1 to 14/2
1938-39	67·7	9·8	0·45	10·3	11·4	1·1	0·451	3·6	85·8	22·7	865·0	84·7	98·6	18/12 to 20/2
[illegible] 1937-38	70·4	9·4	0·56	10·0	11·1	1·1	0·466	5·8	85·6	21·1	666·0	61·9	73·5	..

Co 312 gave the highest outturn of 920·64 maunds per acre in 1937-38, and 940 maunds in the following season, but its maturity was somewhat delayed owing to the heavy manuring practised at the farm, and a larger number of irrigations than is usually given in the United Provinces.

The most important factors to be kept in mind in connection with the specific object of this survey are the ash content of the juice and the saline coefficient, the latter being the ratio between sucrose and ash. The canes from this farm showed the highest ash content and the lowest saline coeffieient of any examined in the United Provinces, and were accordingly poorer in quality. It may be noted that in the 1937-38 season, yields from all varieties were lower than in 1938-39, probably owing to the attack of pyrilla in the former season, which was more severe at this place than at any other surveyed in the United Provinces.

Bisokhar

Bisokhar is one of the villages situated in the new sugar development centre of the United Provinces and its soils are good sandy loams as their average composition given below shows :—

Percentage on air-dried soil

Depth	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sand
1st foot	0·0580	0·840	6·67	0·118	0·032	0·080	13·6	16·8	69·6
2nd foot	0·0420	0·474	7·22	0·134	0·028	0·100	19·1	16·5	64·4
3rd foot	0·0336	0·484	6·86	0·154	0·028	0·160	22·9	18·9	58·2

These soils contain a smaller percentage of water-souble salts than those of the Meerut farm, whilst the organic matter and total nitrogen content is much the same.

Four chief varieties were examined at Bisokhar, viz. Co 244, Co 312, Co 313 and Co 331 (Table III). The last two had received a dressing of a mixture of ammonium sulphate and castor cake at the rate of five maunds per acre, which may have been responsible for the high ash content of the juice. It is interesting to note that the ash content of Co 244 and Co 312, which were unmanured here, was much less than that of the corresponding manured cane at the Meerut farm. This suggests that manuring may be one of the causes responsible for an increase in the amount of mineral matter in the juice of cane. The purity coefficient figures of the manured Co 313 and the unmanured Co 244, both of which are early-ripening varieties, indicate that manuring delays ripening—an observation which is also borne out by a consideration of the analytical data for Co 313 at Amroha which received no manures.

TABLE III

Analytical data of the varities of cane grown at village Bisokhar (1937-38)

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 244 . .	68·1	11·1	0·53	11·6	12·4	0·8	0·302	4·9	89·5	39·4	350·0	38·4	43·4	3/12 to 16/2
Co 312 . .	71·0	9·2	0·78	10·0	11·1	1·1	0·237	8·5	85·3	38·9	550·5	50·7	55·1	16/2
Co 313 . .	70·3	10·3	0·36	10·7	12·1	1·4	0·647	3·5	85·1	16·3	640·5	66·0	77·5	17/12 to 16/2
Co 331 . .	70·4	9·1	0·66	9·8	11·9	1·1	0·497	6·1	85·0	19·1	650·0	59·1	72·1	19/1 to 16/2
Average . .	70·0	9·9	0·58	10·5	11·9	1·4	0·420	6·1	85·0	23·4	547·8	53·7	62·0	..

impur

This village situated about three miles from Muzaffarnagar has light loam s similar to those of the Meerut farm, but they tend to become heavier below first foot. The average composition of these soils is given below :—

Percentage on air-dried soil

pth-	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sand
foot	0·0588	0·710	6·25	0·120	0·030	0·160	15·7	25·9	58·3
foot	0·0532	0·307	6·25	0·166	0·046	0·160	25·7	28·2	46·1
foot	0·0504	0·226	6·25	0·200	0·025	0·080	30·7	28·3	40·7

This soil is heavier than those of Bisokhar and Amroha and is adequately n nitrogen, organic matter and exchangeable calcium, and a uniform *p*H of 6·25 down to 3 ft. in depth was found, indicating its acidic nature.

The four varieties examined here, viz. Co 213, Co 244, Co 312 and Co 313 e IV) were all ripe at the end of November or in the first week of Decem- nd their low ash content and high saline coefficients show them to be ior to the canes from Meerut and Bisokhar. The outturn, however, was r. Co 312, for example, a heavy yielding cane gave only 425 maunds of per acre. Compared with Amroha canes all varieties showed a low saline ient but gave higher yields.

TABLE IV

Analytical data for the cane varities grown at village Salimpur

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 244 : 1937-38	69·9	11·4	0·58	12·0	13·0	1·1	0·349	5·0	87·2	33·7	375·0	42·7	48·7	8/12 to 20/2
1938-39	64·7	10·9	0·22	11·1	12·3	1·2	0·286	2·7	87·8	38·0	400·0	45·6	49·2	4/12 to 28/2
Co 213 : 1937-38	67·5	10·7	0·39	11·1	12·3	1·2	0·478	3·7	87·0	29·9	350·0	37·4	43·0	8/12 to 20/2
1938-39	65·7	10·3	0·48	10·8	12·3	1·5	0·408	5·0	83·6	25·1	370·0	38·1	45·5	4/12 to 28/2
Co 313 : 1937-38	70·0	11·4	0·39	11·8	12·8	1·0	0·421	3·4	89·1	27·9	410·0	46·1	52·5	8/12 to 20/2
1938-39	64·0	11·3	0·29	11·6	12·8	1·2	0·385	2·7	88·7	29·5	400·0	45·2	51·2	4/12 to 26/1
Co 312 : 1937-38	70·8	9·7	0·90	10·6	11·7	1·1	0·340	9·3	82·9	29·5	425·0	41·2	49·7	8/12 to 20/2
Average : 1937-38	69·6	10·8	0·57	11·4	12·5	1·1	0·397	5·4	86·6	28·4	390·0	41·9	48·5	..
1938-39	64·8	10·8	0·33	11·1	12·4	1·3	0·359	3·4	86·6	30·9	390·0	42·3	48·6	..

roha

This village is situated in the Rohilkhand division and lies near the hills, r for this reason the rainfall is considerable, and the climate more humid h that of Meerut and Bisokhar or the south-eastern districts of the Punjab. nay be seen from the table below, the soil is a sandy loam and, as judged its content of organic matter, exchangeable calcium, water-soluble salts n total nitrogen, is the poorest of all the soils of the four localities investi-ed in the United Provinces. It is interesting to record that although the nual rainfall at Salimpur and Amroha is practically the same as each place, n other climatic aspects are similar, yet the Amroha soils contain the least unt of exchangeable calcium of any of those examined during this survey er in the United Provinces or the Punjab. The Amroha soils are very and this may partially account for their low content of exchangeable um—an observation which appears to hold good also for the soils of chli in the Punjab. The average composition of the Amroha soils is as ws :—

Percentage on air-dried soil

pth	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sand
oot	0·0392	0·484	6·40	0·060	0·044	0·070	12·2	15·6	68·1
foot	0·0384	0·484	6·18	0·098	0·035	0·050	19·7	18·2	62·3
oot	0·0280	0·484	5·92	0·100	0·021	0·060	22·2	18·1	59·7

All the four varieties examined at Amroha (Table V), viz. Co 213, Co 312, 3 and Co 331 matured early and had a low ash content but a high purity cient, sucrose content and saline coefficients. Thus, the quality of the was the best of any in the United Provinces or the Punjab. For example, 1 had a sucrose content of 10·1 per cent, whilst the other three varieties nore than 11 per cent. It may be noted, however, that whereas the y of cane produced was excellent, the outturn per acre was the lowest . Co 213, which gave high yields at other places, gave only 256 maunds he per acre at Amroha. From the factory point of view, quality is more tant than quantity, but the cultivator's chief concern is quantity and in espect intrests conflict.

TABLE V

Analytical data of cane varieties grown at Amroha

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 213 : 1937-38	68·1	11·2	0·35	11·6	12·6	1·0	0·364	3·1	88·9	33·0	256·0	28·7	32·2	12/2 to 22/2
1938-39	63·9	11·4	0·35	11·8	13·0	1·2	0·318	3·6	88·3	36·6	220·0	25·1	28·6	11/12 to 19/2
Co 312 : 1937-38	71·7	11·2	0·54	11·7	12·6	0·9	0·219	4·8	88·9	60·1	350·0	39·2	44·1	6/1 to 22/2
1938-39	68·5	11·5	0·51	12·0	12·9	0·9	0·188	4·7	89·2	62·2	300·0	34·5	36·0	30/11 to 19/2
Co 313 : 1937-38	66·6	11·9	0·34	12·3	13·1	0·8	0·243	2·9	90·8	52·3	300·0	35·7	39·3	12/12 to 22/2
1938-39	65·6	12·3	0·25	12·6	13·8	1·2	0·246	2·2	89·6	52·3	270·0	33·2	37·2	30/10 to 12/2
Co 331 : 1937-38	69·0	10·1	0·78	10·9	11·8	0·9	0·213	7·7	85·6	49·0	341·7	34·5	40·3	12/12 to 22/2
1938-39	66·0	12·0	0·32	12·3	13·5	1·2	0·188	2·8	90·0	70·0	290·0	34·0	39·1	30/11 to 19/2
Average : 1937-38	68·9	11·1	0·50	11·6	12·5	0·9	0·260	5·1	88·6	42·7	312·0	34·5	39·0	..
1938-39	66·0	11·8	0·33	12·1	13·3	1·1	0·225	3·5	89·3	55·3	270·0	31·9	35·2	..

In this connection the following comparative figures for Meerut and mroha are of interest :—

Maunds per acre

Locality	Season	Yield	Sucrose	Glucose	Ash	Available cane-sugar
eerut	1937-38	666·0	62·0	3·84	3·10	49·6
	1938-39	822·0	81·8	2·46	3·74	66·2
verage	..	744·0	71·9	3·15	3·42	57·9
nroha	1937-38	312·0	34·5	1·56	0·82	31·2
	1938-39	270·0	31·9	0·81	0·62	28·9
verage	..	291·0	33·2	1·19	0·72	30·1

It will be seen that, considering both the seasons, the amount of white gar which could be obtained from an acre of sugarcane at Meerut was almost ouble that from the same area at Amroha, and from the point of view of the ltivator attempts to increase the yield deserve encouragement, but there opears to be a limiting point beyond which an increase in tonnage reflects in decrease in quality. The interests of the factory and the cultivator cannot identical so long as the price of cane is fixed irrespective of quality. Another oint noted in connection with the cane crop at Amroha was that the canes pened from five to seven weeks earlier than those at Meerut. All factors hich tend to increase the vegetative growth must delay ripening, and of these e amount of irrigation and manure applied are the most important. However, we find that the total amount of water, i.e. rain plus irrigation, applied to e cane crop at Amroha and at Meerut, was the same. As we have seen, the eerut canes investigated received, in the 1937-38 season, five maunds of a xture of castor cake and ammonium sulphate, and it is problematical whether this amount of manure could have delayed the ripening of cane by as long a five weeks. It is to be noted, however, that in the season 1938-39 the canes a Bilari were heavily manured, for in addition to the basic dressing of green anure with 300-400 maunds of sunn-hemp they received also two maunds of amonium sulphate and 15 maunds of castor-cake per acre. These canes pened about the end of January, whereas the Meerut canes which had received ss manure than the above ripened about the middle of December, and the Amroha canes which were raised without any manure were ripe as early as the end of November. It would seem, therefore, that manuring does delay ripening, and in proportion to the amount of manure applied. Another characteristic of the crop at Amroha was the fact that during both the seasons the ash content of the cane, after it had reached maturity, progressively decreased as long as the cane remained standing in the field.

It will thus be seen that the juice from canes at this station showed a low ash content and high purity and saline coefficients. Although the soil was not particularly good yet Amroha produced the best sugarcane found in the United Provinces and the Punjab. Co 313 in 1938-39 had a sucrose content of 12·3 and the others only slightly less. Although the cane produced was of very high quality yet the outturn per acre was low and thus suited the needs of the factories, but was not so satisfactory from the cultivator's point of view, where quantity matters most.

Bilari (1938-39 only)

The soil of this village in the Moradabad district is a medium loam, rich in nitrogen, organic matter and exchangeable calcium and has an acidic reaction. For average composition see below :—

Percentage on air-dried soil

Depth	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sand
1st foot	0·056	0·684	6·19	0·106	0·0740	0·100	15·8	22·0	62·20
2nd foot	0·0504	0·555	6·42	0·186	0·0468	0·060	30·0	20·0	50·0
3rd foot	0·0420	0·439	6·67	0·178	0·0521	0·060	35·2	..	..

Four varieties of cane were examined, namely Co 213, Co 312, Co 313 and Co 331 (Table VI). All were green manured with sunn-hemp with the addition of two maunds of ammonium sulphate and 15 maunds of castor-cake per acre with the result that the outturn of cane was heavy compared with other places in the United Provinces. This heavy manuring not only delayed maturity but also decreased the sucrose content and the purity coefficient and increased the ash compared with the unmanured Amroha canes. The recovery of sugar by the open-pan system as reported by the Sugar Experiment and Testing Station at Bilari was only 5·5.

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 213	71·4	9·6	0·80	10·4	11·9	1·5	0·396	8·4	80·5	25·4	600·0	57·6	71·4	15/1 to 22/2
Co 312	70·0	11·0	0·63	11·6	12·7	1·1	0·255	6·4	86·5	43·0	850·0	93·5	108·1	20/2 to 22/2
Co 313	71·3	10·7	0·85	11·6	12·9	1·3	0·282	9·9	82·6	44·7	800·0	85·6	103·2	8/12 to 22/2
Co 331	68·3	9·9	0·59	10·5	11·4	0·9	0·270	4·1	86·4	37·6	1100·0	108·8	125·4	15/1 to 22/2
Average	70·2	10·3	0·71	11·0	12·2	1·2	0·281	7·2	83·9	47·7	837·5	86·3	100·2	..

TABLE VII

Analytical data for cane varieties, grown at Shahjahanpur (1938-39)

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 213	68·6	9·5	0·59	10·1	11·5	1·4	0·271	9·8	83·5	35·9	600·0	57·0	67·8	2/12 to 27/2
Co 312	66·1	10·4	0·51	10·9	12·0	1·1	0·247	5·9	87·0	42·1	800·0	83·2	96·0	2/12 to 27/2
Co 313	68·4	11·8	0·24	12·0	13·1	1·1	0·304	3·2	89·6	38·8	700·0	88·5	98·3	2/12 to 27/2
Co 331	66·4	10·1	0·45	10·6	11·6	1·0	0·238	6·4	86·2	47·6	800·0	80·8	92·8	2/12 to 27/2
Average	67·6	10·4	0·42	10·8	12·0	1·2	0·266	6·3	86·6	41·1	737·5	77·3	88·3	..

Shahjahanpur (1938-39 only)

The Shahjahanpur district is excellently suited for sugarcane havin annual rainfall of about 40 in. and a good acid sandy loam soil, low in wa soluble salt content. For average composition see table below :—

Percentage on air-dried soil

Depth	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sa
1st foot	0·0448	0·400	6·24	0·072	0·0637	0·076	8·0	8·40	83
2nd foot	0·0364	0·362	6·40	0·132	0·0498	0·080	16·2	34·80	4[illegible]
3rd foot	0·0280	0·324	6·67	0·132	0·0310	0·080	18·0	14·20	67

Four varieties of cane were examined, viz. Co 213, Co 312, Co 313 an 331 (Table VII) which were green manured with sunn-hemp plus two ma of castor-cake and one maund of ammonium sulphate. The outturn of which was of good quality, was greater than that from Amroha and Salin but inferior in quality to the Amroha cane. The yield was from 600 to maunds per acre and all varieties matured early in December.

The Punjab

The Karnal and Rohtak districts are regarded as the best sugar growing tracts in the Punjab, the climate being more suitable for cane anywhere else in the province, with the result that in normal years high y are obtained. Four localities were selected for the investigation, viz. T Jaukhli, Rohat (near Sonepat) and Karnal.

Tharu

It will be seen from the table below that the soil of this village is a loam, rich in organic matter, total nitrogen, exchangeable calcium and w soluble salts. The soil is acidic in reaction and becomes more so with inc ing depth. It has the following average compositions :—

Percentage on air-dried soil

Depth	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt
1st foot	0·0840	1·035	6·75	0·176	0·081	0·200	32·2	23·3
2nd foot	0·0588	0·484	6·30	0·248	0·042	0·156	30·5	25·4
3rd foot	0·0532	0·469	6·30	0·232	0·042	0·140	32·8	22·7

Particulars	Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
	Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 244 : 1937-38	71·0	10·3	0·55	10·9	12·0	1·1	0·370	5·3	85·8	27·5	750·0	77·2	90·0	15/2
1938-39	65·8	8·9	0·75	9·7	11·0	1·3	0·341	8·9	81·0	25·1	800·0	71·2	88·0	..
Co 312 : 1937-38	73·2	6·1	1·30	7·4	8·4	1·0	0·687	21·1	72·2	10·1	850·0	51·8	71·4	16/1
1938-39	64·3	9·9	0·48	10·4	11·8	1·4	0·331	4·8	83·0	30·0	850·0	84·10	100·3	..
Co 313 : 1937-38	72·0	9·4	0·62	10·0	11·2	1·2	0·599	6·6	83·9	15·6	810·7	76·1	90·7	15/2
1938-39	64·9	10·1	0·41	10·5	12·0	1·5	0·452	3·8	83·8	23·8	800·0	80·0	96·0	..
Co 331 : 1938-39	63·0	8·6	0·79	9·4	10·9	1·5	0·439	9·0	78·9	20·2	875·0	75·2	93·4	..
Average : 1937-38	72·1	8·6	0·82	9·4	10·5	1·1	0·545	11·1	80·6	17·7	803·6	68·3	84·0	..
1938-39	64·4	9·4	0·61	10·0	11·4	1·4	0·391	6·6	81·7	24·7	831·0	77·8	87·97	..

As already noted the crop suffered particularly severely at this place pyrilla in 1937-38, hence the analytical data regarding the composition c cane cannot be regarded as normal. Of the three varieties, viz. Co 244, Co Co 313 (Table VIII) examined in 1937-38, Co 312 gave the highest yielc the lowest sucrose content, and had the highest ash content, hence a low s coefficient.

In the following season, however, due to a higher sucrose and lowe content the saline coefficient was the highest of all the varieties examined where in the Punjab during the two seasons, although the figure was o same order as that obtained at Meerut which provided the poorest qu canes in the United Provinces. The higher sucrose was due to the absen pyrilla, but it is difficult to explain why a low ash content was obtained.

The average yield for the two seasons, however, was almost as goo that obtained at Karnal.

Rohat Harsana

The soil of this village as shown below is a sandy loam and the lig of all the soils examined in the Punjab during the survey :—

Percentage on air-dried soil

Depth	Total nitrogen	Organic matter	pH	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	S
1st foot	0·0728	0·776	6·94	0·158	0·028	0·180	18·1	20·4	6
2nd foot	0·0560	0·484	6·28	0·182	0·032	0·220	23·1	19·5	[illegible]
3rd foot	0·0525	0·371	6·14	0·218	0·002	0·240	25·1	17·6	[illegible]

The soil is rich in total nitrogen, organic matter, exchangeable cal and has an acid reaction.

Five varieties of cane were examined, viz. Co 213, Co 285, Co 301, C and Co 313 in the first season, and four in the second, viz. Co 244, Co 312, (and Co 331 (Table IX). In 1937-38 as a result of pyrilla none of the matured. Nevertheless, the outturn was very high, Co 312 with 815·5 m per acre, giving the best yield. The quality of the cane, however, was nat very poor.

In 1938-39, all the four varieties examined matured early in Dece the sucrose content of Co 331 (10·5 per cent) being the highest while t Co 313 the lowest (9·7). The quality of cane resembled that grown at K with a high ash content and a low saline coefficient. Yields were ap mately 750 maunds per acre.

Particulars		Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
		Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 213 :	1937-38	71·9	7·7	0·62	8·3	9·9	1·6	0·646	8·1	79·3	11·9	570·0	40·5	50·4	11/2
Co 285 :	1937-38	68·3	7·1	0·50	7·6	9·4	1·8	0·707	7·0	78·9	10·0	700·0	60·8	73·5	11/2
Co 301 :	1937-38	73·5	8·5	0·77	9·3	10·8	1·5	0·680	9·1	72·0	12·5	775·0	65·8	83·7	14/2
Co 312 :	1937-38	72·8	8·8	0·56	9·4	10·8	1·4	0·465	6·4	81·5	18·4	815·5	71·7	88·1	2/2 to 24/2
	1938-39	63·9	10·1	0·39	10·4	11·7	1·3	0·476	4·0	84·8	21·2	820·0	82·8	95·9	1/12 to 12/2
Co 313 :	1937-38	69·6	9·1	0·47	9·6	10·9	1·3	0·628	5·2	83·5	16·6	790·4	71·9	86·1	2/12 to 24/2
	1938-39	60·1	9·7	0·30	10·0	11·6	1·6	0·457	3·1	84·0	20·7	760·0	73·7	88·2	1/2 to 12/2
Co 331 :	1938-39	63·1	10·5	0·26	10·8	12·2	1·4	0·415	2·5	85·8	23·1	690·0	72·4	84·2	1/12 to 12/2
Co 244 :	1938-39	62·6	10·4	0·279	10·7	12·1	1·4	0·470	2·4	85·9	22·1	780·0	81·1	94·4	1/12 to 12/2
Average :	1937-38	71·2	8·2	0·58	8·8	10·2	1·4	0·628	7·2	79·7	13·9	746·2	62·8	73·5	
	1938-39	62·4	10·2	0·31	10·5	11·9	1·4	0·439	3·0	85·1	21·8	762·5	77·9	90·7	

TABLE X

Analytical data for cane varieties grown at village Jankhi

Particulars		Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
		Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 244 :	1937-38	70·1	9·9	0·55	9·7	10·9	1·2	0·714	6·1	83·5	13·5	555·0	50·5	80·5	20 1 to 25 2
	1938-39	66·1	10·3	0·21	10·5	12·0	1·5	0·510	2·3	83·1	21·4	600·0	61·8	72·0	7 12 to 19 2
Co 312 :	1937-38	73·3	8·7	0·65	9·4	10·4	1·0	0·432	7·5	82·5	20·4	628·3	54·7	66·0	17 2 to 25 2
	1938-39	67·6	10·9	0·16	11·2	12·5	1·3	0·551	1·8	87·6	19·4	700·0	70·3	77·0	7 12 to 19 2
Co 313 :	1937-38	70·8	8·8	0·47	9·3	10·9	1·6	0·637	5·3	81·1	13·9	615·7	54·2	67·1	25 2
	1938-39	64·5	10·0	0·20	10·2	11·7	1·5	0·648	1·9	85·0	17·3	650·0	65·0	76·0	7 12 to 19 2
Average :	1937-38	71·4	8·9	0·56	9·5	10·8	1·3	0·594	6·3	82·4	15·9	599·7	53·1	64·5	
	1938-39	66·1	10·4	0·28	11·0	12·0	1·0	0·585	2·0	86·2	19·4	650·0	67·7	75·0	

is is a typical village of the *khadar* tract, whose soil is a medium loam
ıracterized by a highly alkaline reaction, low exchangeable calcium
ı water-soluble contents. The average composition is shown below :—

Percentage on air-dried soil

.	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sand
	0·0728	0·986	7·97	0·072	0·037	0·220	16·3	31·6	52·1
	0·0588	0·807	8·11	0·074	0·014	0·220	20·1	37·2	42·8
	0·0476	0·524	7·91	0·060	0·019	0·240	22·6	42·7	34·7

is soil had the lowest exchangeable calcium content of any of the soils
ed in the Punjab—a fact which appears to be reflected in the ash con-
the cane juice particularly in the case of Co 244 which was 0·71 per
Jaukhli but only 0·37 per cent at Tharu. Compared with other
es in the Punjab even in the abnormal season of 1937-38, Jaukhli pro-
only medium quality canes (Table X). In the following season all
ee varieties matured early and had a moderately good sucrose content,
ash content and a low saline coefficient, thus resembling the other canes
area.

nes examined at Karnal were taken from the Government Agricultural
which, as will be seen from the data below, has a clay loam soil rich in
matter, total nitrogen and exchangeable calcium. The concentration
er-soluble salts, however, is rather high and the soil reaction acidic.

Percentage on air-dried soil

h	Total nitrogen	Organic matter	*p*H	Exchangeable calcium	Available P_2O_5	Water-soluble salts	Clay	Silt	Sand
	0·0756	1·000	6·50	0·190	0·014	0·160	23·0	31·5	45·5
	0·0483	0·936	6·42	0·220	0·037	0·110	29·1	29·2	41·8
	0·0462	0·855	6·22	0·228	0·019	0·130	31·0	28·5	40·5

Of the four varieties examined in 1937-38, viz. Co 285, Co 312, Co 3 Co 331 (Table XI), Co 312 and Co 331 were badly attacked by pyrilla, y only 5 per cent and 4·5 per cent sucrose on cane, respectively. Co 31 hte highest yield. All the four varieties had low purity coefficients an glucose ratios, both the sucrose content and saline coefficients being low crop showed a tendency to lodge. In the following season all the four va examined, viz. Co 213, Co 312, Co 313 and Co 331 matured in the mi December. The ash content of the juice was very high, but as regard co tion, the cane was in no way inferior, to that on the Government Fa Meerut, where improved methods of cultivation were followed. The s content and ash were equal at both these localities, but the weight o produced per acre was higher at Karnal by 100 maunds than at Meer

General observations

Ripening of sugarcane

It will be seen from Tables II-XI that the yield of stripped cane Punjab was about 40-50 per cent higher than in the United Provinces, shows that the Punjab canes attained a more vigorous and greater vege growth than those in the neighbouring province. Hence, they must rem the field for a longer period before they are fully mature, since all factors increase vegetative growth cause delay in ripening. Again we see th Punjab soils are richer in organic matter, total nitrogen and water-s salts and are much more heavily manured than the United Provinces The number of irrigations given is also greater, but, taking into conside the higher rainfall in the United Provinces, the total amount of water re by the sugarcane crop, both as irrigation and rain water, is usually the It is thus clear that, while most of the canes in the United Provinces w fit for crushing early in the season, the same varieties will be unripe i Punjab. If, therefore, the same varieties of cane are crushed in the two at the same time, the United Provinces canes being fully ripe will nat give a greater recovery.

Quality and yield of sugarcane

The data for the season 1937-38, relating to the quality and quant cane varieties which are common to the two tracts, are given in Table

It will be seen from these figures, that apart from Co 331 which gav total solids and sucrose per acre in the Punjab than in the United Prov all the varieties examined gave a greater outturn of stripped cane, su and total solids in the Punjab. The quality of cane, however, as judged the amount of sucrose and ash expressed as percentage on cane, purity saline coefficient, was much poorer in the Punjab.

Similar data for the following season 1938-39 are given in Table It will be observed that this was a better season for cane both in the U Provinces and the Punjab, specially in the latter where the cane crop bene from better climatic condition and was also free from pyrilla, with the r that the sucrose percentage on cane was almost as good as in the U Provinces. Similarly the ' cane ratio ' and net rendiment showed ma improvement. The yield of stripped cane per acre increased by over

Analytical data for cane varieties grown at Karnal

Particulars		Percentage on cane							Glucose ratio	Purity coefficient	Saline coefficient	Yield per acre in maunds			Ripening period
		Juice	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash				Cane	Sucrose	Total solids	
Co 285 :	1937-38	75·5	7·7	1·44	9·1	10·1	1·0	0·505	18·7	76·9	15·5	613·3	47·2	61·9	27/12
Co 213 :	1938-39	65·0	10·0	0·36	10·4	12·0	1·6	0·579	3·8	83·1	17·3	650·0	65·0	78·0	9/12 to 23/2
Co 312 :	1937-38	68·5	5·0	1·50	6·5	7·7	1·2	0·358	30·0	65·8	13·8	757·3	37·8	58·3	28/2
	1938-39	69·2	10·4	0·29	10·7	12·1	1·4	0·398	3·8	85·5	26·1	1265·0	131·6	155·1	9/12 to 23/2
Co 313 :	1937-38	67·2	7·9	0·76	8·7	9·7	1·0	0·420	9·7	81·9	18·8	612·1	48·3	59·3	28/2
	1938-39	67·2	10·9	0·29	11·2	12·9	1·7	0·495	2·9	84·0	22·0	820·0	89·4	105·8	19/12 to 23/2
Co 331 :	1937-38	72·3	4·5	2·18	6·7	6·9	1·2	0·509	48·4	65·3	8·4	551·3	24·8	38·0	28/2
	1938-39	66·6	10·0	0·48	10·5	11·9	1·4	0·462	3·5	83·5	21·8	1000·0	100·0	119·0	9/12 to 23/2
Average :	1937-38	70·9	6·3	1·47	7·8	8·6	1·1	0·448	26·7	72·5	14·1	633·5	39·5	54·4	
	1938-39	66·9	10·3	0·34	10·6	12·2	1·6	0·481	3·5	84·1	21·8	934·0	96·5	114·0	

TABLE XII

Average composition of sugarcane in the Punjab and the United Provinces and other relative data, 1937-38

Province	Percentage on sugarcane						Purity coefficient	Saline coefficient	Maunds per acre		
	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash			Stripped cane	Sucrose	Total solids
						Co 213					
United Provinces	11·0	0·53	11·5	12·6	1·1	0·42	87·0	27·9	303·0	33·0	37·6
Punjab	7·7	0·49	8·2	9·7	1·5	0·65	79·3	11·9	570·0	43·9	56·4
						Co 244					
United Provinces	10·7	0·57	11·3	12·2	0·9	0·33	87·4	32·4	437·1	46·1	53·0
Punjab	9·7	0·55	10·3	11·5	1·2	0·47	84·6	20·5	652·5	63·3	75·2
						Co 312					
United Provinces	9·7	0·75	10·5	11·5	1·0	0·26	84·1	37·5	559·2	53·0	60·1
Punjab	8·0	1·0	9·0	10·3	1·3	0·52	75·5	15·4	762·7	54·0	71·0
						Co 313					
United Provinces	10·9	0·34	11·2	12·3	1·1	0·38	88·5	28·7	474·6	67·9	57·9
Punjab	8·5	0·58	9·1	10·3	1·2	0·52	82·6	16·2	682·2	83·5	75·8
						Co 331					
United Provinces	9·4	0·65	10·1	11·2	1·1	0·33	83·6	28·7	533·0	49·4	56·7
Punjab	4·5	2·18	6·7	8·0	1·3	0·51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Average relative data

Particulars	United Provinces	Punjab
e per cent on cane	10·3	7·7*
r cent on cane	0·342	0·539
coefficient	86·1	77·5
coefficient	30·1	14·3
atio	11·7	19·2
ndiment or available sugar	8·55	5·2
	Maunds	Maunds
ed cane per acre	461·3	643·9
e per acre	49·9	53·9
solids per acre	53·4	63·3

A low figure due to pyrilla

ds in the Punjab and by 150 maunds in the United Provinces, this increase being due to the fact that the figures for Bilari and Shahjahan- vhere large quantity of manure are generally applied, were included in verage for this season.

n considering the relative features which have been described in regard growth of cane obtained in the two provinces, both from the quantita- nd qualitative aspects, the most important point perhaps to bear in mind t the ash content and 'solids non-sugars' in the juice from the Punjab are considerably higher than in those from the United Provinces. This doubt, due to the higher concentration of water-soluble salts in the b soils, whereas in the United Provinces the soils are lighter and thus permeable. The cane ratio or the number of tons of cane required to ce a ton of sugar is higher in the Punjab than in the United Provinces. ratio is a function not only of the concentration of sucrose in the juice lso of its purity, the latter being the ratio of sucrose to total solids in the The greater the proportion of mineral matter, the more difficult it is over sugar in the process of manufacture. Nitrogenous manuring tends rease the percentage of impurities in the juice and consequently the cane to a greater degree than might be expected solely from a consideration ferences in sucrose content. Consequently a relatively large percentage ar remains unrecovered in the factory when cane is grown under heavy ring. However, some of these factors counterbalanced each other when aring the sugar recovery from the canes of the western United Provinces he south-eastern Punjab, and it was found on balance that the difference ot greater than about one per cent.

n order to gain more accurate data as to how far different nitrogenous res affect the composition of cane juice, Co 312 was manured at the ahanpur Sugarcane Research Station with 100 lb. and 200 lb. of nitrogen re in the form of castor-cake, ammonium sulphate and farmyard manure two, four and six irrigations. The data from these investigations are in Tables XIV-XVI, from which it will be seen that the sucrose content

TABLE XIII

Average composition of sugarcane in the Punjab and United Provinces and other relative data, 1938-39

Province	Percentage on sugarcane						Purity coefficient	Saline coefficient	Maunds. per acre		
	Sucrose	Glucose	Total sugars	Total solids	Non-sugars	Ash			Stripped cane	Sucrose	Total solids
					Co 213						
United Provinces	10·2	0·55	10·8	12·1	1·3	0·332	84·3	32·2	397·0	40·2	48·5
Punjab	10·0	0·37	10·4	12·0	1·6	0·567	83·3	17·6	610·0	61·0	73·0
					Co 244						
United Provinces	10·9	0·22	11·1	12·3	1·2	0·286	88·6	38·1	400·0	43·6	49·2
Punjab	10 7	0·23	10·6	12·1	1·5	0·479	85·9	21·7	723·0	75·2	87·5
					Co 312						
United Provinces	10·6	0·50	11·1	12·2	1·1	0·267	86·9	39·7	722·0	76·3	87·8
Punjab	10·5	0·29	10·8	12·1	1·3	0·488	86·8	21·5	909·0	95·4	110·0
					Co 313						
United Provinces	11·3	0·40	11·7	13·0	1·2	0·331	86·9	34·1	578·0	65·3	75·1
Punjab	10·3	0·27	10·6	12·1	1·6	0·511	85·1	21·1	757·0	78·0	91·6
					Co 331						
United Provinces	10·4	0·44	10·8	12·0	1·1	0·290	86·7	35·9	764·0	79·4	91·7

Average relative data

Particulars	United Provinces	Punjab
e per cent on cane	10·7	10·4
er cent on cane	0·314	0·504
coefficient	87·0	85·9
coefficient	34·1	20·6
atio	11·4	12·0
ndiment or available sugar	9·18	8·35
	Maunds	Maunds
ed cane per acre	611·1*	776·2
e per acre	63·9	78·8
solids per acre	73·6	90·3

The average outturn was higher this season as Bilari and Shahjahanpur were included large quantities of manure are applied

lepressed and ripening delayed as the quantities of nitrogen applied in- d. No particular increase in the ash content of cane manured with nium sulphate was found, but the increase was significant when farmyard re was employed. Generally speaking it may be stated with reasonable ction that the amount of solids non-sugars in cane may be expected to se in proportion to the amount of manure employed.

RAL CONCLUSIONS AS TO THE CAUSES RESPONSIBLE FOR THE ALLEGED NFERIOR QUALITY OF PUNJAB CANES COMPARED WITH UNITED PROVINCES ANES FOR SUGAR PRODUCTION

The general results of the survey indicate that the poor quality of the b canes is mainly due to the composition of the soil of the province— lusion which has stimulated investigators to see to what extent the ash nt of the juice can be lowered by altering the composition of the soil e application of appropriate chemicals such as gypsum. There is ten- evidence already that gypsum may be efficacious for this purpose in soils.

n regard to operations in sugar factories it will be seen from the appendix the mineral content of the clarified juice is lowered to a greater extent carbonation process rather than the sulphitation process is employed, s the Punjab has plenty of lime available this industry should flourish tain localities provided judicious agricultural operations are followed, due taken of the likelihood of frost in the localities selected and the carbona- process followed in factories.

TABLE XIV

Sugarcane analysis

(Sugarcane Experiment Station, Shahjahanpur, 1939)

Date of analysis	Variety of cane	Description of sample	Percentage on juice					Glucose ratio	Purity coefficient	Saline coefficient	Percentage on cane			Remarks
			Sucrose	Glucose	Total solids	Non-sugars	Mineral matter				Juice	Sucrose	Total solids	
22/1	Co 312	Control N_1	13·8	1·04	16·7	1·9	0·412	7·3	82·9	33·4	66·7	9·2	11·1	Six irrigations
,,	,,	Castor-cake N_2	13·3	1·17	16·4	1·9	0·345	8·8	81·6	40·4	66·7	8·9	10·9	100 lb. nitrogen
,,	,,	,, N_3	12·6	1·65	16·1	1·9	0·345	12·9	78·0	38·6	67·7	8·5	10·9	200 lb. nitrogen
,,	,,	Control N_1	14·8	0·64	17·3	1·9	0·430	3·9	86·1	38·5	67·7	9·9	11·5	
,,	,,	Ammonium sulphate N_2	13·5	1·59	16·5	1·6	0·300	10·2	80·9	55·1	68·6	9·3	11·5	100 lb. nitrogen
,,	,,	,,	12·2	1·75	15·3	1·3	0·214	14·3	79·8	56·2	68·1	8·9	11·3	200 lb. nitrogen
,,	,,	Control	14·3	0·77	16·9	1·8	0·397	5·6	84·5	46·2	68·8	9·8	11·6	
,,	,,	F. Y. M. N_2	13·9	0·90	16·6	1·8	0·360	6·2	83·8	43·1	66·6	9·3	11·1	100 lb. nitrogen

(Sugarcane Experiment Station, Shahjahanpur, 1939)

Date of analysis	Variety of cane	Description of sample	Percentage of juice					Glucose ratio	Purity coefficient	Saline coefficient	Percentage of cane			Remarks
			Sucrose	Glucose	Total solids	Non-sugars	Mineral matter				Juice	Sucrose	Total solids	
23/1	Co 312	Control N_1	14·7	1·03	18·1	2·4	0·325	7·0	81·4	45·5	65·0	9·6	11·8	Four irrigations
,,	,,	Castor-cake N_2	12·7	1·63	16·0	1·7	0·443	12·9	79·0	28·5	65·6	8·3	10·5	100 lb. nitrogen
,,	,,	,, N_3	13·5	1·20	16·8	2·1	0·389	8·9	80·5	34·8	67·3	9·1	11·3	200 lb. nitrogen
,,	,,	Control N_1	14·2	0·80	17·4	2·4	0·429	5·7	81·4	33·0	65·0	9·2	11·3	
,,	,,	Ammonium sulphate N_2	12·7	1·58	16·1	1·8	0·399	12·4	79·4	35·6	66·6	8·5	10·7	100 lb. nitrogen
,,	,,	Ammonium sulphate N_3	13·0	1·35	16·4	2·0	0·292	10·2	78·8	46·3	68·8	8·9	11·3	200 lb. nitrogen
,,	,,	Control N_1	14·3	0·63	16·9	2·0	0·456	4·3	85·1	31·4	67·7	9·7	11·4	
,,	,,	F. Y. M. N_2	13·6	1·0	17·1	2·5	0·451	7·2	79·1	30·0	64·3	8·7	11·0	100 lb. nitrogen
,,	,,	F. Y. M. N_3	13·8	0·66	17·1	2·6	0·501	5·0	80·8	27·6	70·0	9·7	12·0	200 lb. nitrogen

TABLE XVI

Sugarcane analysis

(Sugarcane Experiment Station, Shahjahanpur, 1939)

Date of analysis	Variety of cane	Description of sample	Percentage of juice					Glucose ratio	Purity coeffi-cient	Saline coeffi-cient	Percentage of cane			Remarks
			Sucrose	Glucose	Total solids	Non-sugars	Mineral matter				Juice	Sucrose	Total solids	
24/1	Co 312	Control N_1	14·7	0·76	17·5	2·0	0·430	5·2	84·4	34·3	62·5	9·2	10·9	Two irrigations
,,	,,	Castor-cake N_2	13·8	1·38	17·2	2·0	0·236	10·0	79·8	58·4	63·2	8·7	10·9	100 lb. nitrogen
,,	,,	,, N_3	13·0	1·29	15·8	1·5	0·301	9·9	82·2	43·4	67·5	8·3	10·7	200 lb. nitrogen
,,	,,	Control N_1	15·4	0·88	17·9	1·6	0·271	5·7	86·6	56·9	66·7	10·3	11·9	
,,	,,	Ammonium sulphate N_2	12·0	1·31	15·2	1·9	0·292	8·9	79·4	41·1	67·4	8·1	10·2	100 lb. nitrogen
,,	,,	Ammonium sulphate N_3	14·0	1·02	17·0	2·0	0·280	7·3	82·2	49·7	63·2	8·8	10·7	200 lb. nitrogen
,,	,,	Control N_1	13·0	0·96	15·7	1·7	0·369	7·4	83·5	35·4	69·7	9·1	10·9	
,,	,,	F. Y. M. N_2	16·0	0·69	18·2	1·5	0·433	4·5	85·1	35·1	63·7	9·7	11·4	100 lb. nitrogen
,,	,,	F. Y. M. N.	[illegible]	[illegible]	[illegible]									

Another point of considerable importance brought out during this survey t fact that, although manuring results in an increased yield of cane, it n to lower the quality of the juice, and it appears, therefore, that measures ed to increase the yield of cane should be carefully controlled in conjunc- with the quality of cane obtained so as to ensure that the latter is not sely affected.

The quality and yield of the cane crop depend mainly on : (*i*) climate,) ature of soil and (*iii*) agricultural operations. It is a well-known fact n order to produce one pound of dry matter in an arid region more water e required than to produce the same amount of crop in a humid climate. assume, therefore, the concentration of the soil solution (in more general the amount of water-soluble salts present in the soil) to be the same in the cases, it is likely that the crop grown in a dry climate will take up tain a greater amount of plant food material owing to increased trans- on.

gain, the concentration and nature of the soil solution will depend res- ely upon the amount and nature of soluble salts present in any particular Furthermore, the application of manures as followed in the Punjab with- corresponding increase in the amount of water applied appears to be res- le for an increase in the amount of mineral matter in the cane crop. lering all the factors, it appears that the greater amount of ash present juice from the Punjab canes is the main cause of their alleged inferiority. confirmed by the following figures (1937-38) relating to Sonepat in the b where the cane crop was raised under ordinary zemindari conditions, isokhar and Meerut in the United Provinces, where improved methods tivation depending upon liberal irrigation and application of sufficient es were followed.

will be seen from the figures of purity and saline coefficients for different ies of cane grown at various stations in the two provinces (Tables XII and that the canes from the western United Provinces are generally superior se obtained from the south-eastern Punjab. Nevertheless, as shown , those from Bisokhar and Meerut were not as good as those from Sonepat, se the latter were grown under improved methods of cultivation.

seems that attempts to increase the yield of cane beyond a certain limit ely to result in deterioration of quality unless suitable varieties of cane evolved which will maintain their quality as quantitative production

Percentage on cane

ety	Locality	Juice (per cent)	Sucrose	Glucose	Total solids	Ash	Glucose ratio	Purity	Saline coefficient
3	Sonepat	62·2	12·0	0·1	13·4	0·390	1·0	89·8	30·8
	Bisokhar	69·0	11·5	0·15	13·2	0·528	1·3	86·9	21·7
	Meerut	69·0	10·6	0·23	11·8	0·501	2·1	90·1	21·2
o 1	Sonepat	65·6	10·6	0·30	12·1	0·360	3·0	87·6	29·5
	Bishokhar	71·1	9·6	0·55	11·6	0·404	5·6	82·8	23·8
	Meerut	69·3	9·4	0·36	11·2	0·479	3·8	83·8	19·5

is increased. In this connection mention may be made of an interesti servation made at Amroha, which produced the best canes of any in the Provinces or the Punjab. It was found that the amount of mineral which the cane crop is able to absorb during its growth reaches a ma at maturity, and if the crop remains longer in the field the mineral matter remains stationary or decreases. In other words, once the crop is m there is little likelihood of any further increase in the mineral content juice. Obviously, in this respect early-maturing varieties will have vantage over those which mature late, although their yields must nat be low. Attempts should be made to evolve varieties which will give im yields and yet mature early. Further, such varieties should maintai quality over the entire crushing period as long as they remain standing field.

Summary

It was found during the sugarcane seasons 1935-36 and 1936-3 the recovery of white sugar at the Sonepat Sugar Factory in the south-e Punjab from sugarcane grown in the surrounding areas was only 7·7 pe whereas cane imported from the neighbouring tracts across the river J in the United Provinces gave a recovery of 10·18 per cent. The p investigation was conducted with a view to ascertain the causes respo for this wide difference.

A number of localities were selected in each of the two tracts and the varieties in each were analysed during the sugarcane seasons 1937-38 and 39. The soil from the fields growing these canes was sampled at a num places to a depth of 3 ft. and analysed for different constituents.

It was found that the composition of the soil in the two tracts differs ly in the matter of organic matter, nitrogen and water-soluble salts co the Punjab soils being richer in these constituents. The United Prov soils are inclined to be slightly more acidic and lighter than the Punjab

The analysis of different varieties of cane show that canes grown i Punjab have a slightly lower sucrose and glucose content but contain mineral matter in the juice than corresponding canes in the United Prov These differences are reflected in the higher purity coefficient and signific superior saline coefficient of the cane from the United Provinces.

It has been found that the higher mineral matter in the juice of the P canes is the main reason for the low recovery of white sugar in the Pu

It has been shown that the mineral matter in the juice of sugarcane not increase after the canes have reached maturity. On the other ha certain cases the mineral content has been found to decrease after mat This indicates that early ripening varieties are better suited for the soi climatic conditions of the Punjab. Efforts should, therefore, be direct evolve such varieties and at the same time aim for higher yields.

The carbonation process is better suited than the sulphitation proce the manufacture of white sugar in the Punjab as the former reduces the mi content of the mixed juice during clarification to an extent which is a four times as great as that obtained with the other.

Acknowledgements

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APPENDIX A

the manufacture of white sugar two of the most important methods employed for rification of sugarcane juice in the factory are : —(*i*) the sulphitation process, (*ii*) rbonation process. In the first process lime and sulphur are used as clarifying and in the second carbon dioxide and lime. The latter process is more expensive ne former on account of the greater quantity of lime used but the increase in cost is nsated for by a higher recovery of sugar of better quality. Since the juice of sugar- the Punjab is characterized by the presence of mineral matter in relatively high ts, the process of clarification which will yield clarified juice with a lower mineral t will naturally be better suited to conditions in the Punjab. Data were collected the survey to ascertain which of the two processes is more suited for the Punjab Two factories working within a few furlongs of each other were selected for ac- g these data and the figures obtained are given below :—

Sulphitation process

Particulars	Brix	Pol	Purity	
juice	15·5	11·7	75·7	Average of the 1st fortnight
d juice . . .	17·1	13·2	77·0	
juice	16·0	12·2	76·5	Average of the 2nd fortnight
d juice . . .	18·2	14·2	78·1	
juice . . .	16·3	12·6	77·3	Average of the 3rd fortnight
d juice	18·8	14·8	78·6	
juice	16·6	13·1	78·9	Average of the 4th fortnight
d juice . . .	18·1	14·4	79·7	

verage increase of purity from mixed juice to clarified juice is equal to 1·25

Carbonation process

Particulars	Brix	Pol	Purity	
Mixed juice	15·0	11·3	75·2	Average o
Clarified juice	13·4	10·5	78·0	fortnight
Mixed juice	15·9	12·1	76·3	Average
Clarified juice	14·3	11·3	78·2	fortnight
Mixed juice	16·4	12·6	77·1	Average
Clarified juice	15·3	12·2	79·3	fortnight
Mixed juice	16·5	12·9	78·3	Average
Clarified juice	15·5	12·6	80·9	fortnight

Average increase of purity 2·4

These figures indicate that there is a greater elimination of non-saccharin from the juice by the carbonation process than with the other. The following further show that the elimination of ash is also much greater by the former p being almost four times as great as in the latter.

Particulars	Ash per cent juice
Sulphitation process	
Mixed juice	0·530
Clarified juice	0·474
Mixed juice	0·565
Clarified juice	0·487
Carbonation process	
Mixed juice	0·540
Clarified juice	0·317
Mixed juice	0·548
Clarified juice	0·275

These data show that the carbonation process is better suited for Punjab than the sulphitation process


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...S ON SOME FUNGI ISOLATED FROM 'BLACK POINT' ...FFECTED WHEAT KERNELS IN THE CENTRAL PROVINCES

BY

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(With Plate XXIX and eight text-figures)

...previous publication [Dastur, 1933] it was mentioned that from ' black ...' infected wheat kernels, though they all look alike, more than one ... fungi have been isolated when incubated under aseptic conditions. ...per deals with a study of some of those fungi which have not been as ...orded on wheat kernels.

...e ' black point ' infected seed was surface–sterilized by a brief soak ...n a 0·1 per cent solution of corrosive sublimate or in rectified spirit ...t was planted on moist sterilized filter paper in a sterilized petri dish.

... a majority of cases not more than one fungus at a time was found ...ed with the diseased seed. In those few cases which gave a mixed ... flora the mixture included one or more of the following :—*Aspergillus* ...*icillium* sp., *Mucor* sp., *Fusarium* sp., *Chaetomium* sp., *Alternaria* sp., ...*orium* sp.

...*bolus tritici* n. sp. Dast.

... some rare cases an ascigerous fungus was isolated from ' black point ' ... kernels ; ' black point ' affected seeds are usually viable ; but those ...h the blackening of the embryo end was caused by this ascigerous ... failed to germinate ; as the number of isolations of this fungus has been ...all it is not possible to conclude that the kernel diseased by this fungus ...s not viable. A few days after the surface-sterilized seed was planted ...r paper in a petri dish under sterile conditions minute wartlike pro-...ces appeared on the seed. Later the pericarp ruptured and globose or ...bose black bodies, the perithecia, became distinctly visible ; similar ...were also seen scattered amongst the hyphae which had spread from the ...l seed to the filter paper. No other organism was found associated ...is fungus. On the filter paper the perithecia are scattered ; on the seed ...e at first scattered but later they become crowded together forming a ...ceous, brittle, crust-like mass. The perithecia on the kernels are not ...led in its tissues but are formed on the outside of the pericarp partially ...ded by a cob-web of dark coloured hyphae. There is no development ...oma (Plate XXIX, fig. 1). On agar media and sterilized wheat stalks, ... bran the perithecia are similarly developed ; they are erumpent, and ...d or gregarious. They have generally a prominent neck especially ...rmed on the ' black point 'affected kernel (Plate XXIX, fig. 2), but at ...he neck is absent. This is particularly so in the case of perithecia

developed on culture media (Plate XXIX, fig. 3). They are globose, sub-g or flask shaped, usually glabrous ; but at times there is a d ment of undifferentiated hyphae ; the perithecia are black in colou neck when present is cylindrical and has a fringe of hyaline c the tip. The walls of the perithecia are thick but fragile ; they break even under slight pressure. The perithecia with the beak m $219 \cdot 8$—$596 \cdot 6 \times 172 \cdot 1$—$406 \cdot 1\mu$; the body measures 204—550μ ; th measures $53 \cdot 1$—$235 \cdot 9 \times 53 \cdot 1$—$123 \cdot 9\mu$.

The asci are numerous and embedded in filiform paraphyses (Plate X fig. 4). In a mass, asci and paraphyses have a greenish tinge but indivi they are hyaline. The asci are usually long and narrow (Plate XXIX, but at times they are short and broad ; they are straight or slightly cu they are more or less clavate in shape ; the long asci are usually pedicilate XXIX, fig. 6) ; whereas the short ones are sessile with a rounded base XXIX, fig. 7) ; they measure $79 \cdot 8$—$228 \times 13 \cdot 3$—$34 \cdot 2\mu$; usually they m $121 \cdot 6$—$203 \cdot 2 \times 15 \cdot 2$—$22 \cdot 8\mu$. They contain eight ascospores.

Paraphyses are generally inconspicuous, though numerous, and su the asci ; they are very slender, upto $1 \cdot 7\mu$, in width ; they are freq branched, occasionally dichotomously ; they are multiseptate ; not stricted at the septum ; the apex is rounded and slightly broader th rest of the body of the paraphysis.

The ascospores are coiled in a close helix (Plate XXIX, fig. 8); they u escape from the asci through an opening formed at the apex by the disso of the apical part (Plate XXIX, fig. 5). At times they escape from the end of the ascus, and occasionally from both the ends simultaneously. helix of the ascospores emerges through the opening it gets uncoiled ; wh whole mass of coiled ascospores is out of the ascus they are usually comp free from each other and are scattered some distance away from the At times only a few ascospores escape from the helix and the remaining spores are still confined in a loose helix. The ascospore is thin, long an coid or horse-shoe or wavy or contorted in shape (Plate XXIX, fig. 9) ; straight ; and, therefore, its length cannot very accurately be measured apex is slightly rounded ; the basal part tapers gradually and the end is po it is hyaline in colour, but rarely has an olivaceous tinge ; it is many se 4—12 ; at times there is a constriction at the septum ; the ascospores me $125 \cdot 4$—$301 \cdot 6 \times 3 \cdot 8$—$7 \cdot 6\mu$ they germinate readily ; germ-tubes are deve from any or all segments.

In one of the progenies of a culture started from a single ascus, co resembling those of *Helminthosporium* were developed. These conidi light brown or honey coloured, and 5 to 9 septate. In shape they are gen elliptical and straight or slightly curved ; they are not variable in s They are rounded at both ends, have a basal scar and are never forked. measure $45 \cdot 6$—$83 \cdot 6 \times 11 \cdot 4$—$15 \cdot 2\mu$. The germination is bi-polar ; the is firm.

Single spore cultures of this *Helminthosporium* gave only the co stage on Glucose agar and Rice meal agar ; on two per cent plain agar conidia were not developed ; but only empty globular or flask shaped b black or brown in colour, resembling the perithecia described above,

ed ; on sterilized wheat grains and wheat bran perithecia and conidia were loped.

Conidia from a single spore culture of this *Helminthosporium* were used noculating ears of wheat plants grown in pots. The inoculum was placed umes after the flowers had set. The glumes of the grains of the inoculated lets showed typical symptoms of infection. The glumes had the charac- tic tobacco coloured or blackish brown coloured lesions and the kernels ed the typical 'black point'. When these glumes and kernels were ted under aseptic conditions on culture media the ascigerous fungus was ted. The asci measured $126 \cdot 0$—$231 \cdot 0 \times 15 \cdot 75$—$21 \cdot 0\mu$; the ascospores ured $157 \cdot 5$—$345 \cdot 4\mu$.

Surface-sterilized wheat and rice grains were inoculated with this single- e culture of *Helminthosporium*, and incubated in sterilized moist chambers. perithecial stage was not developed but the hyphae produced *Helmintho- um* conidia in large numbers. The conidia on these wheat grains measured —$83 \cdot 6 \times 11 \cdot 4$—$15 \cdot 2\mu$; the number of septa varied from five to eleven. conidia on rice grains were similar to those found on cultures of the erous fungus and measured $38 \cdot 0$—$58 \cdot 8 \times 7 \cdot 6$—$15 \cdot 2\mu$. The septa varied five to nine.

Taxonomy

The genus *Ophiobolus* Riess, in the broad Saccardian sense, can be readily led into two distinct series, the helicoid and the non-helicoid ascigerous s according to the arrangement of the ascospores in the asci. The known ect stages of the graminicolus Helminthosporia belong to the helicoid s. Drechsler [1934] has shown that these graminicolus Helminthosporia characteristics which are sufficiently distinctive and constant to be group- ogether for purposes of classification. He, therefore, has removed this oid series from the original genus *Ophiobolus* and has placed it in a new s, *Cochliobolus*, a name which indicates the helicoid arrangement of the spores. The type species is *C. heterostrophus* (Syn. *Ophiobolus heterostro-* Drechs.), the ascigerous stage of *Helminthosporium maydis* Nishikado et ike on *Zea mays*. Therefore, according to Drechsler, the following bers of the helicoid ascigerous series, *Ophiobolus miyabeanus* Ito et bayashi (Syn. *H. Oryzae*. Breda de Hann) on *Oryza sativa* ; *O. sativus* K. et B.) Ito et Kuribayashi (Syn. *H. sativum* Pammel, *H. acrothecioides* fors) on *Hordeun sativum* Jess. and *Triticum vulgare* ; *O. setariae* Sawada et Kuribayashi (Syn. *H. setariae* Sawada) on *Setaria italica*, *S. glauca* and *viridis* ; *O. kusanoi* Nishikado (Syn. *H. kusanoi* Nishikado) on *rostic major* would now be renamed *Cochliobolus miyabeanus* (Ito et Kuri- ashi) Drechs. *C. sativus* (Ito et Kuribayashi) Drechs., *C. setariae* (Ito Kuribayashi) Drechs. and *C. kusanoi* (Nishikado) Drechs. respectively. ascigerous stage of *Helminthosporium stenospilum* Drechs. on *Saccha- officinalis* belongs to the helicoid series and has been named *Cochliobolus ospilus* by Matsumoto and Yamamoto [1936]. Our fungus, both in its coni- and perfect stages, provides a close parallelism with these six species. re is a marked similarity between the perithecia of these species and our is. They are globose or flasked shaped, black or blackish brown in lur and have a thick pseudo-parenchymatous fragile wall ; the beak of the

perithecium is without setae as in *C. miyabeanus* and *C. heterostrophus* ; j ing from the illustration given by Matsumoto and Yamamoto [1936] the of the perithecium of *C. stenospilus* also seems to be without setae, the is glabrous or may occasionally bear sterile hyphae. The perithecium ma with or without a beak. There is a considerable difference in the size o perithecia of these seven species (Table I).

TABLE I

Size of perithecia and their ostiolar beaks

	Perithecia	Ostiolar beak
C. miyabeanus	370—760 × 370—780μ	95—200 × 55—1
C. sativus	770—530 × 340—470μ	90—150 × 80—1
C. setariae	240—500 × 220—315μ	60—125 × 50—1
C. heterostropus . . .	400 × 400—600μ	150 × 150μ
C. kusanoi	300—350 × 300—350μ	.. ..
C. stenospilus . . .	266—462 × 238—448μ	.. ..
C. n. sp.	220—597 × 172—406μ	53—236 × 56—1

The asci have a general resemblance in size ; the range of variation b in the length and breadth of the asci of our fungus is much greater than tha other species (Table II).

TABLE II

Size of asci and ascospores

	Asci		Ascospores		
	Length	Width	Length	Width	Septati
C. miyabeanus . .	142—235μ	21—36μ	235—468μ	6—9μ	6—
C. sativus . . .	110—220μ	32—45μ	160—360μ	6—9μ	6—
C. setariae . . .	130—150μ	22—32μ	200—315μ	6—7μ	5—
C. heterostrophus . .	160—180μ	24—28μ	130—340μ	6—7μ	..
C. kusanoi . .	130—170μ	14—18μ	140—170μ	5μ	6—
C. stenospilus . .	127—195μ	20—33μ	130—300μ	6—8μ	4—
C. n. sp. . . .	80—228μ	13—34μ	125—301μ	4—8μ	4—

he smallest ascus of our fungus is much smaller than the smallest of the species ; but the maximum measurement is very close to that of *abeanus* and *C. sativus*. In width the smallest measurement is practical- same as that of *C. kusanoi* and the maximum is very close to that of *abeanus*, *C. setariae* and *C. stenospilus*.

the number of ascospores in an ascus our fungus resembles *C. kusanoi* ; have invariably eight ascospores. In *C. heterosporus* the number varies one to four (typically 4) and in the remaining four species it varies from eight.

he range of variation in the length of the ascospores of our fungus is cally the same as that of *C. stenospilus* ; the ascospores of the other s except those of *C. kusanoi* are longer than our fungus. There is no d difference in the width of the ascospores of these species ; the number ta of the ascospores of our fungus is the same as that of *C. stenospilus* e ascospores of both are mostly flagelliform.

he conidia are brown or brownish in colour fusiform or long elliptical in , occasionally slightly curved, five to nine septate measuring 45·6— 11·4—15·2μ ; they have never been observed to be forked ; their wall ; hilum is present. The germination is bipolar, germ tubes have not een to arise from the intermediate cells.

ur fungus does not possess complete similarity with any one of the known s of the helicoid series of the ascigerous stage of the graminicolus Helmin- oria ; though in some individual characters it may resemble one or more se known species. Our fungus is, therefore, considered to be a new species helicoid series. It is congeneric with *Cochliobolus* and the binomial *tici* sp. n. is proposed.

obolus tritici sp. n. Dastur

erithecia scattered or gregarious, black or brownish black, pseudoparen- atous, fragile, flask shaped, with or without ostiolar beak ; bodies se, 220—597 × 172—406μ ; usually glabrous, at times covered with ative hyphae ; beaks, when present, well developed, cylindrical, ·36 × 53—124μ ; asci numerous cylindrical or clavate, straight or slightly d widest below the middle, rounded at the apex ; shortly stipitate at the or sessile hyaline and thin walled 80--228 × 13·0—34·0μ. Paraphyses rous, hyaline, at times dichotomously branched, extremely fine, upto wide, septate. Ascospores, eight in number, disposed in a strongly id arrangement, flagelliform or filiform, obtusely pointed at the apex and ly pointed at the base ; wider at the apical portion than the basal which ering ; four to twelve septate hyaline in colour 125·4—301·6 by 7·6μ. Conidia straight or slightly curved, elliptical with broadly rounded five to nine septate ; basal scar present, wall firm light brown to honey red, 45·6 to 83·6 by 11·4 to 15·2μ; germination bi-polar.

Iab. on kernel of *Triticum vulgare*.

iobolus tritici, sp. nova

Perithecia dispersa vel aggregata, nigra vel brunneo-nigra, pseudoparen- atica, fragilia, amphorae similia, ostiolari rostro praesente vel absente ; ra globosa, 220—597 × 172—406μ ; generatim glabra, non raro tamen

operta hyphis vegetativis ; rostra, si adsunt, bene evoluta, cylir
53—236×53—124μ ; asci plures cylindrici vel clavati, recti vel leviter
latiores sub medio, rotundi in apice ; sessiles vel breviter stipitati in
hyalini, et tenuibus parietibus praediti, magnitudinis 80—228×13·0—
Paraphyses plures, hyalinae, non raro dichotome ramificatae, admodum
les, latitudinis ad 1·66μ, septatae. Ascosporae numero 8, dispo
valde helicoidali ordinatae, flagelliformes vel filiformes, obtusae in apice,
acutae in basi ; latiores ad apicem quam ad tenuescentem basim ;
septatae, colore hyalinae, magnitudinis 125·4—301·6×3·8—7·6μ. C
recta vel leviter curvata, elliptica, extremitatibus late globata, 5—9 se
cicatrix basalis adest ; parietes firmi, colore ex tenuiter brunneo ad me
praediti, 45·6—83·6×11·4—15·2μ ; germinatio bipolaris.

Habitat in seminibus *Tritici vulgaris*.

Type specimens are deposited in the herbaria of the Mycologist t
Government of the Central Provinces and Berar and of the Imperial
logist, New Delhi.

This fungus was isolated some years back from 'black point' af
wheat kernels. During the writer's absence on leave most of the cultu
fungi isolated from this source were lost as a result of a bad infectio
mites. Since then innumerable 'black point' affected wheat kernels
been planted on agar media and moist filter papers but from none of
plantings this fungus has been obtained, though various other fungi previ
secured have been re-isolated. Several methods for the surface sterili
were adopted including the use of chemicals such as silver nitrate which D
[1935] has found to be less toxic than mercuric chloride.

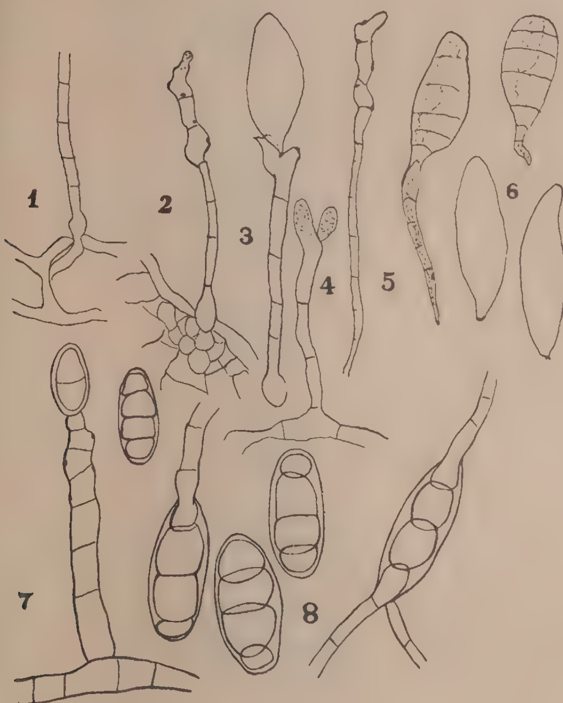
Helminthosporium sp. A

The growth of this fungus on the infected seed is characteristic ; it c
readily differentiated from that of other fungi growing on 'black p
kernels when incubated under moist conditions. The aerial myceliu
scanty, both on the pericarp of the kernel and on the filter paper on whic
kernel is planted. Both the pericarp and the filter paper are covered w
black or sooty powdery mass the conidia and conidiophores.

Conidiophores

Conidiophores on the kernel are developed in two ways ; e
directly from the mycelium in the cells of the host tissue or from the
layer of aerial mycelium developed on the outside of the pericarp. The
celium in the pericarp generally forms a stroma from which the conidio
arises ; but the conidiophore may also arise directly from a hypha in the
epidermal cells. When the conidiophores arise directly from the myce
in the tissues of the kernel, the lower end of the conidiophore is swollen or
bous (Figs. 1-3). But when the conidiophore is borne on the aerial
celium it is a prolongation of a hyphal branch (Figs. 4 and 5) ; the beginni
the development of this conidiophore is marked by slight thickening, swe
and colouring of the terminal cell of this hypha. The conidium is unbranc
it usually arises from the substratum singly and is coloured light br
The number of conidia borne on conidiophores arising from the pericarp o
kernel is small, one to seven, but of those borne on conidiophores in cultu
as much as 17 judging from the number of scars and geniculations presen

phores. The development of conidia is typical of the genus *Helmin-ium.* The conidium is borne terminally ; just below the point of its ment the conidiophore grows onward forming a geniculation and bears r conidium. The process continues making the conidiophore genicu- the number of bends correspond with the number of conidia devel-



osporium sp. A. (× 270)

IG. 1. A conidiophore emerging through an epidermal cell
IG. 2. A conidiophore developing from a stroma
IG. 3. A conidiophore with a conidium
IG. 4. A conidiophore arising laterally from a hypha
IG. 5. A hypha developing into a conidiophore
IG. 6. Conidia, two conidia are germinating

osporium sp. B. (× 600)

IG. 7. A conidiophore developing laterally from a hypha
IG. 8. Conidia, two conidia are germinating

e conidiophores borne on the pericarp measure 41—243μ up to the first geniculation ; their bulbous ends are 5·5 to 11μ in width. The number from the bulbous end up to the first scar varies from three to six.

Conidia

The conidia both on the wheat kernel and on culture vary in shape ; they are obpyriform, obovate spear-head shaped or elo elliptical ; the apex is either broadly rounded or pointed ; there are var between these two extremes ; the conidia are stipitate and have a consp hilum ; the stipe is about 3—9μ long ; they are straight and regular times are crushed out of shape as they are crowded together ; the mature c are dark brown or honey coloured ; the septa are indistinct (Plate X fig. 13) ; they vary from three to seven ; at the basal end there is a di hyaline or lighter coloured area ; the wall is firm.

The germination is invariably from the basal end or the (Fig. 6). The conidia measure $45 \cdot 6—91 \cdot 0 \times 18 \cdot 7—30 \cdot 0\mu$ ger $52 \cdot 0—78 \cdot 0 \times 18 \cdot 7—30 \cdot 4\mu$.

In culture media the growth of this *Helminthosporium* is as characte as on the ' black-point ' kernel. The aerial growth is limited ; the myc forms a thin felt-like growth ; when the conidia develop the colour be greenish black.

Inoculations of wheat seedlings failed to produce lesions on the l or stem ; but when immature ear heads were inoculated the glumes deve lesions and the kernels the typical smudge on the embryo end.

Helminthosporium sp. B.

This *Helminthosporium* differs from the other Helminthosporia isc from ' black point ' affected wheat kernels in the conidiophores and cc being very small, and in the conidia having a constant number of s namely three.

The conidiophores are very sparsely developed directly from the ti of the kernel ; they emerge singly between the epidermal cells of the peric they are scattered ; their basal segment is not swollen. The incubated k on its outside is covered by a layer of brown mycelium from v conidiophores are developed in large numbers. They are generally fo laterally but in some cases they are borne terminally, the brown hypha be a conidium at its apex. The conidiophores that emerge from the host ti or are borne laterally from the hyphae of the mycelial felt are s unbranched, light to dark honey coloured ; the head bearing the conid very slightly broader than the rest of the conidiophore ; it is not strongly j culated at the points of attachment of the conidia ; the scars marking t points are close to each other (Fig. 7) ; up to the first scar the conidiopl have three to five septa and measure $23 \cdot 0—53 \cdot 2 \times 3 \cdot 5\mu$; the numbe conidia borne is small, about two to six.

The conidia are elliptical in shape, both ends are similar and bro rounded ; the basal end is distinguished by a not too prominent hilum ; conidial wall is smooth, firm and thick, light to dark honey coloured ; the s are three and clearly visible ; the germination is from each end, never i intermediate cells ; usually it is from the hilum end that the germ-tube develops ; only one germ-tube is developed from each end ; but from the of the lowermost cell a side branch is often developed (Fig. 8). The cor measure $18 \cdot 75—30 \cdot 0 \times 7 \cdot 5—11 \cdot 25\mu$.

This *Helminthosporium* is not the same as *H. triseptum* Drechs. isol from velvet grass, *Notholcus lanatus* by Drechsler [1923]. *H. triseptum*

conidia, 35—50 × 15—21 μ ; they are dark olivaceous in colour and ate only from the basal end.

1e coleoptile and stems of seedlings inoculated with this fungus develop brown lesions ; the roots turn brown. ' Black point ' affected kernels leveloped from inoculated flower heads.

phoma sp.

iis disease is first noticed on wheat ears. The infected immature heads iter green in colour than the healthy heads ; this difference in colour is ble only when the ear is green ; when it matures and turns brown the of the infected ear is the same as that of the healthy ear. A few or all kelets in a ear may be affected. The infection is first seen on the outer it commences as a minute pale brownish speck ; it enlarges elliptically ne length of the palae forming a diffused lesion and ultimately may cover ater part of the palae ; the diseased area later turns tobacco brown ; at stage the central part of the lesion turns lighter in colour, pale straw d or slivery grey coloured ; the lesion thus has a distinct dark brown , the outline of which is not sharply defined. In the pale coloured centre ycnidia are developed ; they are not scattered but are arranged in rows 1 the vascular strands or veins. The infection may spread to the inner nous palae ; the lesion is diffused and tobacco brown in colour ; pycni- near rows are developed on the inner palae as well. The kernel may be eloped or shrivelled or aborted. The infected kernel does not necessarily black smudge at the embryo end ; the lesion is usually a brown l line on the furrow, other parts of the pericarp may also be affected. insverse sections of a glume or a pericarp through a lesion with pycnidia iat they may originate in cells just below the epidermis, so that the pycnidium looks as if it had developed superficially, or they may in the inner tissues, in which case the mature pycnidium fills practically le thickness of the glume or the pericarp (Plate XXIX, figs. 10 and 11). ost tissues the pycnidia do not seem to be embedded in a stroma (Plate figs. 10 and 11). The pycnidia burst through the epidermis. When point ' affected kernels are planted on moist filter paper and incubated chambers under aseptic conditions at room temperature the fungus develop a prominent growth of the aerial mycelium ; it is scanty and out fan-like on the filter paper ; the colour is brownish or blackish On the filter paper the pycnidia are formed singly, are scattered and ial ; there is no trace of the presence of a stroma. On the incubated lso the mycelial growth is very scanty and appressed to the pericarp. nidia may be crowded together but there is no development of a stroma. media also pycnidia are without a stroma. They are thick walled, us to carbonous, pear shaped or sub-globose, and bear a short but beak (Plate XXIX, fig. 12). When seen from above under high magni- a distinct ostiole or opening is visible ; the ostiole is not minute ; are absent or obsolete ; the pycnidia measure 38—53 × 152—228 μ. idia escape from the ostiole in a long tendril or worm-like mass. They ine elliptical or ovoid, one celled and non-guttulate. They measure 7 × 1·7—3·0 μ ; conidia when placed in water swell considerably and

become bi-cellular before they germinate. Germ tubes are developed both ends.

Wheat seedlings and ears inoculated with this fungus gave positive r Brownish to blackish elongated lesions were formed on the stem ; on the g typical diffused elongated tobacco coloured lesions develop ; on the k enclosed by the inoculated glumes the embryo end was discoloured a times there were also lesions on the pericarp.

Taxonomy

Our fungus belongs to the family *Phomaceae*, sub-family *Hyalos* In this sub-family, it is very near the genus *Phoma* Fr., em Desm. Acc to Saccardo [1884] in *Phoma* the pycnidia are not beaked, the ostiole is r or obsolete, and the spores are mostly two-guttulate. As our fungus h these characteristics it is doubtful if it can be placed in this genus. Th portant difference between this genus and *Pseudophoma* v. Hoehn., acc to Clements and Shear [1931], is that the latter has rostrate pycnidia a spores are hystogenic. Von Hoehnel [1916] gives the following descript the new genus created by him :—'Stromata sub-epidermal ganz pycnide lich, mit allseitig gleichmassing entwickelter, gut abgegrenzter Kruste mit schnabelartigem Fortsatz, der (allein) nach aussen durchbricht. Co je eine aus einer Gewebszelle des Stromainnern histolytisch entstehend, drisch-stabchenartig, zeimlich gross, durch den schliesslich oben ausbrocke Schnabelfortsatz entleert.' * On wheat glumes and kernels thick bodies, brown to black in colour are developed in the tissues of the host, letely or partially filling the thickness of the glume or the pericarp ; whet some cases at least, these pycnidial bodies are 'stromata ganz pycnide lich', it is difficult to say ; but in cultures, on agar media wheat stem bran and on moist filter papers, there is no stromatic development ; shaped or globular thick-walled pycnidia with a short but distinct bea developed, singly or in clusters ; the beak is clearly ostiolate. The conid not seem to be developed by hystolysis ; the basidia are obsolete.

As our fungus has rostrate pycnidia with a distinct ostiole it is provisio placed in the genus *Pseudophoma* v. Hoehn., even though it does not w answer to the description given by v. Hoehnel.

Pseudophoma sp.

Pycnidia sub-epidermal, without stromata, thick-walled, coria to carbonous, pear shaped or sub-globose, with a short beak, osti 38—53×152—228μ ; basidia obsolete ; conidia hyaline, elliptical or one-celled, non-guttulate, escaping through the ostiole in long te $5{\cdot}0$—$6{\cdot}7 \times 1{\cdot}7$—$3{\cdot}0\mu$; germination bi-polar ; when placed in water co swell and become bi-cellular.

Nigrospora sphaerica (Sacc.) Mason

A Nigrospora was isolated both from the 'black point' affected w kernels and from spotted glumes of rice (*Oryza sativa*).

*My thanks are due to Dr G. W. Padwick, Imperial Mycologist, and Dr Mundkur, Assistant Imperial Mycologist, Imperial Agricultural Research Institute, Delhi, for very kindly supplying me the original descriptions of *Phoma* and *Pseudop*

e growth of the fungus on wheat kernels incubated on moist filter under aseptic conditions is white and sparse ; later the mycelium is appressed to the surface of the kernel and the filter paper ; it does not compact mass ; the white colour is soon replaced by a diffused black or sh colour—a sort of pepper and salt colour—on account of the develop- f conidia bearing hyphae which are brown in colour. The conidia are ingly on short swollen or vesicular basidia, which may be hyaline or n colour. The conidia are broadly elliptical with rounded ends or are bular, when seen from the side ; they are round when seen from x ; they are deep, dark brown or black in colour and opaque ; under agnification they are seen to have a central lighter coloured globular he short diameter of the conidium is in continuation of the vertical axis basidium. The conidia borne on the mycelium originating from the ed wheat kernels are smaller than those produced in cultures. The measure $13 \cdot 0$—$19 \cdot 0 \times 9 \cdot 5$—$15 \cdot 0\mu$; those developed on rice meal agar s measure $15 \cdot 0$—$26 \cdot 0 \times 11 \cdot 0$—$18 \cdot 7\mu$. The *Nigrospora* isolated from rice glumes is similar to that isolated from wheat kernels.

yake [1910] has described *Epicoccum hyalopes* Miyake on rice glumes in which to Mason [1927], from the description given, 'seems undoubtedly *Nigrospora*'. As the conidia measure 14—18 × 13—15μ, Mason con- to be *N. sphaerica* (Sacc.) Mason. Palm [1918] has described *nica* Palm from wheat glumes. The conidia measure 22—30μ ; they ch bigger than those developed by the fungus isolated from wheat and us. This fungus is, therefore, considered to be *Nigrospora sphaerica* Mason.

culations of seedlings and ears of wheat and rice isolated from these two ave given negative results.

um rolfsii Sacc.

numerable 'black point' affected kernels have been incubated under conditions ; but this sclerotial fungus, was isolated only from half a ernels.

is fungus was identical with that isolated from roots of wilted wheat and of other hosts such as tomatoes, potatoes etc. It is, therefore, not ry to give a detailed description of the fungus.

culations of wheat seedlings and green ears were successful.

nia sp.

is fungus has often been isolated from 'black point' wheat kernels and otted glumes of rice (*Oryze sativum*).

rice glumes at first a brownish speck is visible ; this increases in size lly ; ultimately the centre of the lesion turns white and the margins brownish black. The white or the central part of the lesion is dry and depressed, it ultimately cracks ; minute black sclerotia-like bodies are even with the naked eye in the white part of the lesion. The lesion hed only to the glume ; the rice grain or seed is normal.

e sclerotia are globular and black in colour ; they measure $\times 23$—61μ.

culations of wheat and rice seedlings and ears were unsuccessful.

Summary

An account of some fungi not previously recorded on 'black p affected wheat kernels is given. The fungi described are *Cochliobolus* n. sp., *Helmithosporium* sp. A. and *H.* sp. B., *Pseudophoma* sp., *Nigro sphaerica* (Sacc.) Mason and *Rhizoctonia* sp. *Sclerotium rolfsii* Sacc. has been isolated from 'black point' affected kernels.

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EXPLANATION OF PLATE XXIX

Cochliobolus tritici n. sp.

Fig. 1. Section of a wheat pericarp through a perithecium
Figs. 2 & 3. Perithecia with and without beaks
Fig. 4. Asci with paraphyses
Fig. 5. A group of asci
Fig. 6. A stipitate ascus
Fig. 7. A non-stipitate ascus
Fig. 8. Asci showing the helicoid arrangement of ascospores
Fig. 9. Ascospores

Pseudophoma sp.

Fig. 10. Section of a wheat pericarp through pycnidia
Fig. 11. Section of a wheat glume through pycnidia
Fig. 12. Pycnidia with beaks

Helminthosporium sp. A

Fig. 13. A group of conidia

THE FIXATION OF ELEMENTARY NITROGEN BY SOME OF THE COMMONEST BLUE-GREEN ALGAE FROM THE PADDY FIELD SOILS OF THE UNITED PROVINCES AND BIHAR

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Introduction

T the present time, evidence has been adduced to show that one of the probable causes for the preservation of the fertility of the paddy field s is through the fixation of atmospheric nitrogen. In this connection [1929] has demonstrated the presence of a nitrogen-fixing bacterium hin the root of the rice plant, after the manner of the Leguminosae, while wanath [1932] has obtained indications that the rice plant itself possesses power of assimilating elementary nitrogen. De [1936], working with ixed culture of algae and bacteria, came to the conclusion that the fixa- of nitrogen in rice soils under water-logged conditions is an algal pro- , while the absence of fixation in the cultures kept in the dark implies t bacteria cannot alone be involved. De and Bose [1938] found that in water-logged period conditions are unfavourable for certain bacteria *Azotobacter* which are unlikely to be very active at this time. By far most important works on this subject have been those of Fritsch and De 38] and De [1939]. They have concluded that nitrogen-fixation in these is purely through the agencies of algae and the part played by bacteria elatively unimportant and possibly nil. They further found that nitro- -fixation was confined to species of *Anabaena*, while *Phormidium foveola-* afforded no evidence of fixation. Lately Uppal, Patel and Daji [1939] e shown that *Azotobacter* plays an important rôle in the nitrogen recupera- of rice soils at Karjat.

The present work arose out of the observation that in the paddy field of the United Provinces and Bihar there is an universal growth of a it community constituted mainly by *Aulosira fertilissima* Ghose inter- gled with filaments of *Anabaena ambigua* Rao, *Anabaena fertilissima* and *Cylindrospermum gorakhporense* Singh. This association forms a k and compact stratum, and sometimes it becomes so extensive as to r the surface of a field completely, interrupted only at places where paddy its grow out. At the close of the harvest period the above blue-greens observed to be reproducing freely by spores. After a fortnight or so as found that the plants disintegrated and died, leaving behind only spores for perennation. The presence of a large number of spores in the

upper layers of the soil was availed of, and it was thought des to start cultures with these spores because of the little chances of cont tion from bacteria and fungi.

For the sake of comparison *Protosiphon botryoides* (Kütz.) Klebs *parieticola* Iyengar, a member of the Chlorophyceae, was isolated f paddy field of the Benares district. It was observed that the vesicles alga contained a number of thick-walled cysts, some of which were also l ed in the soil. After a week the plants died leaving behind only the The cultures in the present case were, therefore, started with the cysts

Culture methods and isolation of the algae

The culture solution used for the growth of these organisms wa modification [1939] of Benecke's solution [cf. Kufferath, 1930] substi KNO_3 for NH_4NO_3. Its composition is as follows: KNO_3, 0· $MgSO_4 \, 7 \, H_2O$, 0·2 gm.; $CaCl_2$, 0·1 gm.; $KHPO_4$, 0·2 gm.; $FeCl_3$, (1 per 2 drops; water (pyrex distilled), 1,000 c.c. In some experiments ste soil-extract was used as the basal medium; in others where the eff changes in pH of the culture medium on growth of the algae and their gen-fixing capacity was to be studied the above modification of Ben solution was buffered with potassium phosphates (mono-, di-, or tri phates) to give the desired pH; while still in others where the impo of K and Ca ions on growth and activity of these plants was invest various other modifications were used. In some cases nitrogen-free were utilized and those generally used were: (1) modified Benecke's so with the omission of KNO_3, (2) solution containing, K_2HPO_4, 0·5 $MgSO_4.7H_2O$, 0·2 gm.; $CaSO_4$, 0·1 gm.; $FePO_4$, 0·1 gm.; Ca_3 (1·0 gm.; $FeCl_3$ (1 per cent), 2 drops and water (pyrex distilled), 1,00

In order to obtain uni-algal cultures the following method was adopt Soil blocks without the least disturbance of the surface layers were brou the laboratory and examined under a dissecting microscope. This reve large number of spores mostly on the surface of the soils. Also, the sp the different species of algae under consideration were found in groups, th facilitating a good deal of their isolation, which was carried out as fo The lumps of spores were removed from the soil with a pair of hot need a clean sterilized glass slide in a drop of sterilized water and under the scope the adhering soil particles were, as far as possible, removed. Ne spores were transferred with hot forceps to a test tube containing a sterilized distilled water and closed with a rubber stopper and shaken rously. The suspension was then allowed to stand for 15 minutes and t pernatant turbid liquid was decanted off. This process was repeated s times until the supernatant liquid became perfectly clear. Finally the and in the case of *Protosiphon botryoides* the cysts along with a few c.c. liquid were transferred to a sterilized centrifuging tube in sterilized di water and centrifuged. The suspension was further diluted five time again centrifuged. A loopful of this suspension was pipetted out by of a hot pipette and transferred to several agar plates, and these wer exposed to light when after 15 or 20 days many showed good growth. N ous filaments radiated from the points of inoculation, and single ho

es were selected and their positions marked with Indian ink under a micro-pe. Portions of the agar including such marked areas were then cut out, l transferred to the liquid medium mentioned previously and allowed to w in 250 c.c. pyrex Erlenmeyer flasks.

For getting bacteria-free cultures silica gel plates were utilized. The ca gel was prepared by mixing equal volumes of hydrochloric acid (sp. 1·1) and potassium silicate solution (sp. gr. 1·06). Merck's sodium sili-e pure crystals were used and the solution was made up with cold water. a number of 9 cm. Petri dishes, 40 c.c. portions of the mixture were placed l after 48 hours when the gel had hardened, the plates were first washed running tap water until free from acid and subsequently several times h boiled distilled water. Each plate was then impregnated with 5 c.c. he following solution : KNO_3, 0·1 gm. ; $MgSO_4.7H_2O$, 0·1 gm. ; K_2HPO_4, 2 gm. ; $CaCl_2$, 0·1 gm. ; $FeCl_3$ (1 per cent), 1 drop ; water (pyrex dis-ed), 100 c.c. Finally the plates were exposed to a temperature of 60° C. il the surface of the gel was fairly dry and then sterilized in an autoclave a pressure of one and a half atmosphere for 20 minutes.

A loopful of the centrifuged suspension containing at the most five res or cysts on the average was pipetted out and transferred by means a hot sterilized pipette to the centre of a sterilized silica gel plate and spread r the surface by means of a hot glass rod. After this the plates were ex-ed to diffused light obtained from a north window in the laboratory. It k about a month or so for the spores to germinate and form algal fila-nts and in the case of the cysts the time taken was a little longer. After appearance of the filaments a little of each was transferred to one of the -extract-nitrate-cane-sugar-agar plates described below, and, if found taminated, fresh sub-cultures on silica gel were made as above and the cess repeated. When one or more colonies were obtained, which appeared be pure when tested by the above method, they were transferred to a culture dium and allowed to grow for sometime. They were finally tested for purity the methods described below. In this way *Aulosira fertilissima*, *Cylindro-rmum gorakhporense*, *Anabaena ambigua*, *A. fertilissima* and *Protosiphon yoides* forma *parieticola* were obtained in pure cultures.

The following media, both solid and liquid, were used for testing the ity of the cultures : (1) nutrient agar, (2) soil-extract-nitrate-cane-sugar-r (De's modification of Beneeke's solution given above with 50 c.c. soil-ract and 15 gm. cane-sugar), (3) Beijerinck's medium containing 20 gm. nnite, 0·2 gm. K_2HPO_4, and 1,000 c.c. tap water, (4) medium containing er cent mannitol, 0·2 gm. K_2HPO_4 in 1,000 c.c., 10 gm. $CaCO_3$ in 1,000 and 1,000 c.c. tap water. Several drops of a suspension of the supposedly e algal growth were inoculated into the above media, which were then ubated for a week in the dark at 25° C., the presence or absence of turbidity l growth of bacterial colonies along the line of inoculation in liquid and d media respectively, being taken as an index of the presence or absence bacteria.

The isolation from bacteria by growing the algae on sterilized silica gel tes was also started with the uni-algal filaments but it was observed that ne of the cultures produced turbidity when grown in the testing media.

It is, therefore, concluded that it is safer to start with spores in orde obtain pure cultures.

Nitrogen analyses were made by the macro-Kjeldahl method. At end of an experiment the entire contents of the culture vessel (mediu alga) were poured into a Kjeldahl flask, any growth adhering to the si the vessel being washed out with pure conc. sulphuric acid. Total nitr was estimated by the Gunning-Hibbard modification of Kjeldahl's me [Wright, 1939]. Digestion and distillation were carried out in the u way, the ammonia evolved being absorbed in $N/15$ H_2SO_4 and estim by back titration with $N/15$ NaOH, using methyl red as an indicator. the determination of small amounts of nitrogen, $N/50$ acid and alka used and the acid boiled to drive off CO_2 before titration.

Pyrex Erlenmeyer flasks of 250 c.c. capacity were used for growing cultures and the mouth of each flask was plugged with cotton-wool. A d empty flasks were, at one time, sterilized in an autoclave at a pressu one and a half atmosphere for 20 minutes. After 24 hours the fl were subjected to a second heating under the same pressure to en the complete elimination of bacteria. Next in each one of these flasks c.c. of the culture medium was kept, the plugs replaced, and the w again heated twice after the manner described above. The flasks were allowed to stand for two days before being inoculated with a suspension the alga in water. All cultures were grown under laboratory condition temperature and pressure. An overhead Philips electric lamp of 250 w provided illumination of constant intensity adjusted to such a height th did not affect the temperature of the surroundings of the cultures. On average the cultures were illuminated for 10 hours daily.

Nitrogen-fixation by the algae

Five replicates were made for each treatment and the experiments conducted in two series. The mean of the replicates and ultimately the m of the series has been taken as the criterion of the nitrogen-fixing capa of the algae in question. The results are presented in Tables I-IV.

1. *Aulosira fertilissima* Ghose. In both the series in all cases the gr of the alga in the beginning was quite rapid and it formed a membra blue-green stratum on the surface of the culture medium, which in mo the flasks extended on the sides above the level of the liquid, irrespe of the medium containing nitrate, or not. After a week's incubation algal stratum, in cultures with nitrate in the medium and especiall those having soil-extract as the basal medium, began to fade out and fi became pale or almost colourless; while in cultures without nitrate, it c nued to retain its bluish-green tinge even after the second week. At the of the second week, however, in some of the flasks, with nitrate and nitrate and soil-extract, patches of green colour began to appear on the signifying thereby the renewed growth of the alga. The algal stra however, never became so thick and compact as that found in na After the third week's incubation the behaviour of the cultures as desc above remained similar and it continued to be so even after the close o experiment.

TABLE I

Nitrogen-fixation by Aulosira fertilissima *Ghose*

(Nitrogen in mg. per 100 c.c. of the medium. Period of incubation 45 days)

edia		First series			Second series			
	Initial N	Final N	N fixed	Mean of replicate	Final N	N fixed	Mean of replicate	Mean of series
(De's modi- of Be- solution KNO_3)	...	7·3	7·3	7·4	7·7	7·7	7·6	7·5
		7·6	7·6		7·4	7·4		
		7·2	7·2		7·6	7·6		
		7·4	7·4		7·5	7·5		
		7·5	7·5		7·8	7·8		
+ soil-ex-	0·4	8·4	8·0	8·08	8·6	8·2	8·02	8·05
		8·5	8·1		8·3	7·9		
		8·5	8·1		8·5	8·1		
		8·6	8·2		8·3	7·9		
		8·4	8·0		8·4	8·0		
+nitrate	2·9	5·8	2·9	2·92	6·0	3·1	2·68	2·8
		6·2	3·3		5·5	2·6		
		5·6	2·7		5·3	2·4		
		5·9	3·0		5·7	2·8		
		5·6	2·7		5·4	2·5		
+nitrate xtract	3·3	11·8	8·5	8·8	11·7	8·4	8·6	8·7
		12·2	8·9		11·6	8·3		
		12·4	9·1		12·0	8·7		
		12·0	8·7		11·9	8·6		
		12·1	8·8		12·3	9·0		

ylindrospermum gorakhporense Singh. The growth of *Cylindrospermum porense* was always submerged and it formed a thick dull-green irregular n on the bottom of the flask. In soil-extract-nitrate medium the growth ow in the beginning and it was not until the commencement of the veek that the algal stratum became visible at the bottom of the flask. free-soil-extract and N-free-nitrate media, however, the growth was apid at the start but after a week's incubation the stratum became nd finally colourless. It renewed growth after the second week's tion. On the whole, in the latter two media, the algal cells were nally developed. The heterocysts were very much elongated and the ntents, which were at first granular became homogenous and pale

Anabaena ambigua Rao. The growth in case of this alga was, in the ing, submerged, the colonies being in the form of narrow cylinders, ng almost erect. Later, however, they had the tendency of rounding

up and coming up on the surface of the culture medium. In the N-
extract and N-free-nitrate media the growth was quick at the sta
after two weeks' incubation the colonies began to lose colour and
diffluent, finally getting mixed up with the medium. In the soil
nitrate medium, however, the algal colonies were quite intact till t
of the experiment.

TABLE II

Nitrogen-fixation by Cylindrospermum gorakhporense Singh

(Nitrogen in mg. per 100 c.c. of the medium. Period of incubation 45 da

Media	First series				Second series		
	Initial N	Final N	N fixed	Mean of replicate	Final N	N fixed	Mean of replicate
1. N-free (De's modification of Benecke's solution without KNO_3)	...	4·5	4·5	4·28	4·1	4·1	4·02
		4·2	4·2		3·8	3·8	
		3·8	3·8		3·9	3·9	
		4·6	4·6		4·2	4·2	
		4·3	4·3		4·1	4·1	
2. N-free + soil-extract	0·4	4·8	4·4	4·68	5·4	5·0	4·78
		5·2	4·8		5·5	5·1	
		5·3	4·9		4·9	4·5	
		5·2	4·8		4·9	4·5	
		4·9	4·5		5·2	4·8	
3. N-free+nitrate	2·9	4·9	2·0	2·46	4·8	1·9	2·3
		5·5	2·6		4·7	1·8	
		5·6	2·7		5·4	2·5	
		5·4	2·5		5·6	2·7	
		5·4	2·5		5·5	2·6	
4. N-free+nitrate +soil-extract	3·3	8·3	5·0	4·82	8·6	5·3	5·0
		7·9	4·6		8·3	5·0	
		7·8	4·5		8·2	4·9	
		8·2	4·9		8·0	4·7	
		8·4	5·1		8·4	5·1	

4. *Anabaena fertilissima* Rao. The growth, in this case, consisted
spherical colonies of blue-green colour at the bottom of the flask.
after a week's incubation aggregated to form irregular bigger colon
the colour changed to brownish-black. In the N-free soil-extract
free nitrate media the growth of the alga was quite quick and it re
so till the close of the experiment. In the N-free and N-free nitra
extract media the growth was slow in the beginning but after the third
incubation it became quite vigorous.

TABLE III

Nitrogen-fixation by Anabaena ambigua *Rao*

Nitrogen in mg. per 100 c.c. of the medium. Period of incubation 45 days)

edia	First series				Second series			
	Initial N	Final N	N fixed	Mean of replicate	Final N	N fixed	Mean of replicate	Mean of series
De's modi- of Be- solution KNO_3)	...	3·8	3·8	3·6	3·5	3·5	3·56	3·58
		3·6	3·6		3·4	3·4		
		3·3	3·3		3·7	3·7		
		3·7	3·7		3·6	3·6		
		3·6	3·6		3·6	3·6		
+soil-ex-	0·4	4·2	3·8	4·06	4·7	4·3	4·22	4·14
		4·6	4·2		4·5	4·1		
		4·5	4·1		4·6	4·2		
		4·6	4·2		4·6	4·2		
		4·4	4·0		4·7	4·3		
-nitrate	2·9	5·0	2·1	2·26	5·3	2·4	2·3	2·28
		5·4	2·5		5·5	2·6		
		4·8	1·9		5·4	2·5		
		5·2	2·3		4·9	2·0		
		5·4	2·5		4·9	2·0		
+nitrate xtract	3·3	9·3	6·0	5·58	8·6	5·3	5·66	5·62
		9·2	5·9		8·9	5·6		
		8·6	5·3		8·7	5·4		
		8·7	5·4		9·4	6·1		
		8·6	5·3		9·2	5·9		

Protosiphon Botryoides (Kütz.) Klebs forma *parieticola* Iyeng. The of the present alga was completely retarded in N-free and N-il-extract media. There was slight growth in the beginning in the -nitrate medium but after the third week's incubation a few vesicles plant were found attached to the sides of the flask above the culture n. In N-free-nitrate-soil-extract medium, however, the growth was ul, and clusters of dark-green vesicles appeared at the bottom and the f the flask. There was, however, no increase in the nitrogen content, meant that the alga was unable to fix nitrogen from the atmosphere. he fourth week's incubation in the last medium the vesicles began to grate fast and within four days the plant died completely, perhaps the deficiency in the nitrogen content of the medium. The same ation was recorded in regard to the N-free-nitrate medium, as the h was completely inhibited after the fourth week's incubation.

TABLE IV

Nitrogen-fixation by Anabaena fertilissima *Rao*

(Nitrogen in mg. per 100 c.c. of the medium. Period of incubation 45 da

Media	First series				Second series		
	Initial N	Final N	N fixed	Mean of replicate	Final N	N fixed	Mean of replicate
1. N-free (De's modification of Benecke's solution without KNO_3)	...	4·6	4·6	4·6	4·7	4·7	4·64
		4·8	4·8		4·9	4·9	
		4·5	4·5		4·5	4·5	
		4·6	4·6		4·4	4·4	
		4·5	4·5		4·7	4·7	
2. N-free + soil-extract	0·4	5·7	5·3	5·3	5·5	5·1	5·14
		5·6	5·2		5·4	5·0	
		5·7	5·3		5·6	5·2	
		5·7	5·3		5·6	5·2	
		5·8	5·4		5·6	5·2	
3. N-free + nitrate	2·9	5·8	2·9	2·76	5·3	2·4	2·74
		5·9	3·0		5·8	2·9	
		5·3	2·4		5·7	2·8	
		5·6	2·7		5·6	2·7	
		5·7	2·8		5·8	2·9	
4. N-free + nitrate + soil extract	3·3	9·8	6·5	6·56	10·2	6·9	6·66
		10·0	6·7		10·0	6·7	
		9·6	6·3		10·0	6·7	
		9·7	6·4		9·8	6·5	
		10·2	6·9		9·8	6·5	

FACTORS DETERMINING GROWTH AND NITROGEN-FIXATION

1. *Illumination.* The optimum light intensity was found to depen marked extent upon the growth conditions, particularly, the medium In nitrogen-free media the growth and the nitrogen-fixation capac *Aulosira fertilissima* Ghose were accelerated to a marked extent with incr light intensity but the cultures could not stand the direct sunlight o high intensity for a long time as after the fifth week's incubation the cells began to disintegrate and finally disappeared completely. In di light, obtained from a north window, the growth proceeded slowly a was not till the end of the third week's incubation that the algal st became visible. Later, however, the growth became greatly increase the vigour of the cultures remained more or less constant till the close experiment. The nitrogen-fixation capacity also increased. These cu were illuminated, on the average, for 10 hours daily. Some cultures kept in the dark, and in these cases the growth appeared to be very and it remained so till the end of the experiment. The nitrogen-

city of the alga also remained almost constant. But, it increased very iderably in such cultures as were provided with 1 gm. of sugar per 100 of the medium. It was, however, found that the best light conditions maximum growth and nitrogen-fixation was intermittent light, i.e., the cultures were daily kept alternately in diffused light and direct for five hours. In media containing nitrogen the growth was greatest irect light, but the nitrogen-fixation capacity of the alga was slightly rded. The reason for the latter behaviour is obvious. The results of above mentioned experiments, carried out with *Aulosira fertilissima* se, are given in Table V.

TABLE V

rowth and nitrogen-fixation by Aulosira fertilissima *Ghose under varying light conditions*

(Nitrogen in mg. per 100 c.c. of the medium. Period of incubation 45 days)

Illumination		Medium used	Growth	N fixed
y period in hours	Light source			
10	Direct sunlight	N-free	Vigorous, retarded totally after five weeks	6·3
10	Direct sunlight	N-free + soil-extract	Vigorous, retarded totally after five weeks	6·8
10	Direct sunlight	N-free + nitrate	Best	4·2
10	Direct sunlight	N-free + soil-extract + nitrate	Best	5·3
10	Diffused light	N-free	Slow in the beginning, increased after third week and remained constant	7·8
10	Diffused light	N-free + soil-extract	Comparatively quick	6·6
10	Diffused light	N-free + nitrate	Quick in the beginning, but after second week it was retarded	2·5
10	Diffused light	N-free + nitrate + soil-extract	Quick in the beginning, but after second week it was retarded	3·8
10	Dark	N-free	Very slow but remained constant	3·5
10	Dark	N-free + 1 gm. sugar per 100 c.c. of medium	Very slow but remained constant	4·5
10	Dark	N-free + soil-extract + nitrate	Very slow and did not continue long	2·3
10	Direct and diffuse light (five hours each)	N-free	Excellent	8·6
10	Direct and diffuse light (five hours each)	N-free + soil-extract	Excellent	7·6
10	Direct and diffuse light (five hours each)	N-free + nitrate	Slow in the beginning	4·7
10	Direct and diffuse light (five hours each)	N-free + nitrate + soil-extract	Slow in the beginning	5·3

2. *Hydrogen-ion concentration.* The effect of pH on growth and nitrogen-ation capacity was studied on *Aulosira fertilissima* Ghose. The results the various experiments are given in Table VI. It is seen from this

table that a neutral or slightly alkaline medium is decidedly preferabl the alga. Growth could not take place below *p*H 6·5. It was initiat *p*H 6·5 and with increasing *p*H it became more and more vigorous normal being realized at 7·2. At higher *p*H values, although the gr to all outward appearances, was vigorous the algal cells were found abnormally elongated, especially the heterocysts. The nitrogen-fix capacity of the alga also increased with increasing *p*H. It has also observed that with longer period of incubation the *p*H of the me begins to decrease, after three weeks' incubation in case of the nitroge media and after a week's incubation in media containing nitrogen. is perhaps due to the disintegration of the algal cells.

TABLE VI

Growth and nitrogen-fixation at different pH *by* Aulosira fertilissima *Gho*

(Nitrogen in mg. per 100 c.c. of the medium. Period of incubation 45 days)

Initial *p*H	Relative growth (after 20 days incubation)	N fixed	Final *p*H
5·2	None	..	5·0
5·5	None	..	5·2
5·7	None	..	5·8
6·0	None	..	5·4
6·3	None	..	6·1
6·5	Slight	2·6	6·0
6·8	Fair	4·2	6·2
7·2	Normal	7·8	6·8
7·4	Vigorous	7·8	7·0
7·6	Vigorous	8·1	7·3
8·0	Abnormal (decaying)	6·5	7·5
8·4	Abnormal (decaying)	5·8	7·3
8·8	Abnormal (decaying)	2·5	7·8

3. *Calcium and potassium ions.* It was reported by Allison, Hoove Morris [1937] that neither calcium nor strontium, at least in concentra greater than traces, was necessary for growth in the presence of com nitrogen for *Nostoc muscorum* Ag. In nitrogen-free medium, nitrogen fix however, decreases greatly in the absence of these ions, suggesting th

ıey play a catalytic role in nitrogen-fixation, as in the case of ıcter. Similar experiments were conducted with *Aulosira fertilissima* The results of these experiments are given in Table VII. These are in close agreement with those of the above mentioned workers ır as the behaviour of the calcium ion is concerned. It has also been ›d that calcium carbonate as against calcium sulphate or calcium e is most effective for growth and nitrogen-fixation. In another series eriments, where basal medium consisted only of K_2HPO_4 and the ıting culture was grown on a calcium-free medium, practically no ı was obtained, except where either combined nitrogen or calcium te was added. Under such conditions the nitrogen-fixation capacity alga also increased.

TABLE VII

of Ca and K ions on growth and nitrogen-fixation in Aulosina fertilissima *Ghose*

ɾen in mg. per 100 c.c. of the medium. Period of incubation 45 days. Basa dium : K_2HPO_4, 0·75 gm. ; $MgSO_4.7H_2O$,0·2 gm. ; NaCl, 0·2 gm. $Cl_3.6H_2O$, 0·005 gm. ; H_2O, 1,000 c.c.)

Treatment	Relative growth (after 20 days incubation)	N fixed
(basal medium)	None	..
10 mg.	Slight	3·2
10 mg.	Slight	1·8
10 mg.	Normal	8·2
10 mg.	Slight	2·3
10 mg. + $CaSO_4$, 10 mg.	Normal	6·8
10 mg. + $CaCl_2$, 10 mg.	Normal	5·7
10 mg. + $CaCO_3$, 10 mg.	Vigorous	8·6

DISCUSSIONS

summary of our knowledge of the occurrence and rôle of blue-green n nature would seem to indicate that these organisms are of considernportance in the maintenance of soil fertility [cf. Bharadwaja, 1940 okes, 1941]. The results obtained by Allison and coworkers [1937] he most active nitrogen-fixing blue-green alga, *Nostoc muscorum* Ag., y maintain it, lend further support to the same viewpoint. A similar sion was reached by Bristol [1920], even though nitrogen-fixing ability tain *Cyanophyceae* had not been demonstrated conclusively at that Petersen [1935], however, is doubtful about the economic importance ae in soil, basing his views largely on the supposition that they make rowth except at the soil surface. He considers that the *Myxophyceae*

with the exception of *Nostoc punctiforme* and possibly a few others, c grow heterotrophically or fix nitrogen in the dark. Author's results another active nitrogen-fixing blue-green alga, *Aulosira fertilissima* G isolated from the paddy field soils of the United Provinces and Bihar tog with the recent results of Allison and coworkers [1937] with *Nostoc mus* Ag. and that of Winter [1935], as quoted by Allison and coworkers [with *Nostoc punctiforme*, definitely contradict these two ideas which in large part as a basis for Petersen's viewpoint. Whether *Aulosira lissima* Ghose actually makes an appreciable growth in soil where light not penetrate still remains to be determined, but it is at least of inter know that it has the capacity to do so. Moreover it has been observed *Aulosira fertilissima* not only makes an appreciable growth in the dar its nitrogen-fixing capacity also remains fairly considerable.

If the results reported here in regard to *Aulosira fertilissima* Gho proved to be typical, it would seem that the nitrogen-fixing blue-greens t best in nearly neutral or slightly alkaline soils, preferably partly shade where moisture is abundant. *Aulosira fertilissima* also shows abun growth in freshwaters, where the pH is very low, and sometimes in disti acidic soils. These studies suggest that even in acid soils it may be ab continue to multiply at the surface, because by growing together and const removing carbon dioxide from the soil during photosynthesis it may inc the pH locally. It has also been observed that it has the tendency to re the pH of the medium during its growth, probably due to the liberatio organic acidic substances during the death and decay of certain of its In short it can be said that the alga has a great buffering capacity. Its tinous sheath also enables the organism to withstand remarkably dry conditions, as Fritsch [1932, 1936] and others have pointed out with N and other blue-greens.

The nitrogen-fixing algae, growing near the soil surface, are uniqu being able to obtain both their carbon and nitrogen from the air. of course, explains why they appear so soon on new volcanic soils and in o places where the soil is too poor to support most other forms of plant li

The results of the various experiments embodied in the text bring two important conclusions : (1) blue-green algae, apart from the sp of *Nostoc* and *Anabaena*, in pure cultures free from bacteria and other mi organisms are able to utilize and fix nitrogen, (2) the green algae ap to take no part in the fixation process, though the observations have limited and confined to only *Protosiphon botryoides* (Kütz.) Klebs forma *par cola* Iyeng. So far as the first one is concerned, it has been observed that results of carefully controlled experiments, on a comparative basis, h shown that *Aulosira fertilissima* Ghose, a very prominent participitant in algal flora of the paddy fields of the United Provinces and Bihar, fixes greatest amount of nitrogen out of the other blue-greens under considerat The results of another series of experiments show that nitrogen-fixation ca city of *Cylindrospermum gorakhporense* Singh, another common blue-gr alga from the same localities, is by no means insignificant. The other fo that were isolated from these soils are *Anabaena ambigua* Rao and *Anaba fertilissima* Rao, which also appear to fix considerable amount of nitro

n the atmosphere. It is legitimate, therefore, to conclude from the above ervations that the recuperation of nitrogen in the paddy field soils of India n algal process, a view expressed also by De [1939]. It may be pointed that the paddy field soils harbour a large number of algae [Singh. 1939 stly blue-greens, that are likely to play an immense role in the economy these soils. Besides their capacity of fixing atmospheric nitrogen they are neficial in aerating the upper layers of the submerged soils [cf. Harrison l Aiyer, 1914].

Again, the present investigation has a bearing upon the theory put forrd by Dhar and coworkers [1934-36], that nitrification in tropical soil nore photochemical than bacterial, and that nitrogen-fixation is a questio energy relations because more of nitrogen is fixed in soils mixed with energy viding materials, such as carbohydrates, celluloses and fats in sunlight or ificial light than in the dark, although the *Azotobacter* numbers in the dark very much greater than in the light. If this hypothesis is correct, then chlorophyll-bearing plants and plant organs should fix atmospheric nitron. But, this is not so, as all attempts to find nitrogen-fixation by higher nts other than leguminous, since the classical work of Hellriegal and Wilth [1888], have failed. The green leaf is undoubtedly the prime source energy on this planet, where a chain of complex chemical reactions involv energy changes and transference take place but no fixation of nitrogen. om the algal side we have the results of numerous investigations which finitely show that the green algae, which by no means are less in their ergy relations to the blue-greens, are unable to fix nitrogen. Kossowitsch 894], by isolating a grass-green alga, *Cystococcus*, in pure culture, found at it could not fix nitrogen. Schramm [1914] worked with seven species the green algae and found that in the absence of combined nitrogen no owth took place, so he concluded that these algae could not under these nditions assimilate free nitrogen. Similar results were also obtained by uerscher [1923] for *Chlorella*. Investigations so far done on nitrogenation have alleged this function in only *Nostoc* and *Anabaena* species, though opeland [1932] mentioned forms, such as *Oscillatoria princeps*, *Osc. formosa*, irulina labyrinthiformis and *Phormidium laminosum*. The present work s added two new forms possessing considerable nitrogen-fixing capacity to e existing list -*Aulosira fertilissima* Ghose and *Cylindrospermum gorakhrense* Singh. The nitrogen-fixing capacity of these plants may perhaps due to their peculiar metabolic activities, about which very little is yet own; and not to some simple energy relations which Dhar and his corkers explain.

Summary

The investigation deals with the nitrogen-fixation ability of some of the mmonest blue-green algae—*Aulosira fertilissima* Ghose, *Cylindrospermum rakhporense* Singh, *Anabaena ambigua* Rao and *Anabaena fertilissima* Rao—lated from the paddy field soils of the United Provinces and Bihar. It s been found that nitrogen recuperation in these soils is an algal process d the greatest fixation, amounting to 8·05 mg. per 100 c.c. of the N-free edium in 45 days, is obtained by *Aulosira fertilissima* Ghose.

For the sake of comparison, a grass-green alga, *Protosiphon botryoid.* (Kütz.) Klebs forma *parieticola* Iyeng. was also isolated from a paddy fiel of Benares district and studied in the same way. It has been found that th alga does not fix nitrogen.

Factors, such as, illumination, *p*H, and the effect of Ca and K ions o growth and nitrogen-fixation ability of *Aulosira fertilissima* Ghose, have als been investigated.

In conclusion, I have much pleasure in expressing my great indebtednes to Professor Y. Bharadwaja, for his kind guidance and criticism throughou the course of this investigation.

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THE COLD STORAGE OF FRUITS IN THE PUNJAB

I. CITRUS FRUITS : MALTA (*CITRUS SINENSIS*) AND SANGTRA (*C. NOBILIS*)

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(With Plate XXX and four text-figures)

OLD storage is absolutely indispensable for the healthy development of fruit industry and it is no exaggeration to say that, but for the exist- e of cold storage facilities in other countries, their fruit industries would not e survived for any length of time. The main reason for this is that most he fruits are so easily perishable that after removal from the trees, they can- be stored even for a few days under ordinary atmospheric temperatures. d storage helps in extending the period of availability of fruits and thus uces considerably the fluctuations in the prices of fruits. This enables the t growers to realize reasonable price for their fruits as they do not have to np their produce in the market at any price. They can release the fruit n the cold storage as and when required to meet the demand of the market. isumers, on the other hand, are able to secure fruits at reasonable price for nger period in the market.

Although the fruit industry in this country has not, so far, made any at progress, still the profitable disposal of fruit has already become an te problem for the growers. For instance, in the Punjab, Malta oranges in ruary can be had at almost Re. 1 to Rs. 2 per hundred, and Sangtra orange ven 12 annas a hundred, yet after two to three months these cannot be had ven five times the price of this. This is the condition in case of citrus fruits ch have got a fairly good keeping quality. And worse is the situation in er fruits and vegetables which cannot be stored for even a day or two under inary atmospheric temperature prevailing in summer. When there is glut he market, which is quite frequent, fruits and vegetables can be had at ost dirt cheap price. Tomatoes in June can be had even at eight annas a ind and the price easily goes up ten times after sometime.

Months of April to June are notorious in regard to the prevalence of many htful diseases like typhoid when medical people in 99 per cent of the cases, not recommend to patients anything else but the use of fresh fruit juices ch are not available at this time of the year except those obtained from t stored in cold stores. In short, the cold storage can prove a boon to the wers and blessing to the consumers and it would be idle to expect sound elopment of fruit industry in the absence of cold storage enterprise.

The importance of this problem was realized long ago and the Fruit Spe- ist, Punjab, had submitted proposals several years back for the installation cold storage plant for experimental purposes but financial stringency always

stood in the way. Fortunately, a vigorous enterprise was started about f years back in the form of Cold Storage Company of Northern India an their request the Imperial Council of Agricultural Research, in active coop tion of the Punjab Government, agreed to start experiments on the cold stor of fruits. The Cold Storage Company supplied a small plant of one and a ton capacity, which was purchased later on by the Punjab Government. Punjab Government and the Imperial Council of Agricultural Research agr to share the other expenses of the cold storage scheme in equal proportions. the plant had a very small capacity, only a few fruits could be experimen upon at a time. Citrus being the most important fruit of the province, turally received special attention although some other fruits like mang pears and grapes were also experimented upon on a small scale. This pa however, deals with the cold storage trials of Malta and Sangtra oran alone.

Review of literature

Cold storage of Malta orange has been a subject of thorough study in ot countries like the United States of America, Australia and South Africa. results obtained in different countries vary considerably. Young and R [1930] working on Valencia and Navel oranges found that 38°F. and 45°F. pectively were suitable temperatures for these fruits and these varieties k well for three to four months and $3\frac{3}{4}$ months respectively at above temperatu There was little change in sugar content of juice during cold storage. At 32 the fruit became bitter in taste after five weeks. Ramsey [1915]—cited by F Nelson [1933]—recommended the employment of temperatures considera above 32°F., i.e. 38°-40°F. for oranges. Overholser [1930]—cited by K markar [1941]—found that the temperatures of 36°-38°F. were most sa factory. At higher temperatures the losses were heavy due to shrinkage a decay and lower temperatures caused pitting of the rind. Friend and B [1932] observed that at 44°-45°F., Valencia orange could be kept very sa factorily for long periods. Wardlaw [1933] stated that 40°F. was well sui for the storage of certain classes of citrus fruits (except limes and grapefru He found that the loss in weight was largely a function of size and matur and was directly related to the area of fruit surface exposed. He also ad cated the use of cellophane or other thin strong wrappers, suitably impregna with wax or other water proofing substances instead of ordinary wrappe Stahl and Camp [1936] found that 37·5°F. proved to be the optimum tempe ture for the storage of unwrapped, untreated oranges and the temperatu below this were better than temperatures above. Stahl, Camp and Fifi [1936] also recommended that wrapping was better than none at all. Sami [1936] working on the gas storage of Valencia oranges remarked that the fru stored at 32°F. and 36°F. kept better and showed no wastage as compared fruits stored at 45°F. and 70°F. Tomkins [1937] stated that 70 per cent relati humidity reduced wastage as compared to saturated atmosphere. If venti tion was sufficiently restricted to allow the accumulation of 10 per cent carb dioxide, wastage might be increased. Cheema, Karmarkar and Joshi [19 found 40°F. to be the best temperature for the storage of Nagpur orang (mandarins) and that washing with antiseptic solution was of no particu

n lengthening the storage life of the fruit. Cheema and others [1939] hat Malta oranges from the Punjab kept for four months at 40°F. in ondition without any wastage. Stahl and Cain [1937] recommended imidity and a temperature of 37°F. with 6 per cent carbon dioxide plus cent oxygen, as the most suitable conditions for the storage of oranges. , and coworkers [1938] stated that 40-42°F. was most suitable tem- e for the storage of Washington Navel oranges at which these kept in ondition for 12 weeks. Storage life of Valencia Late oranges at 40- as 14 weeks. Tomkins [1936] working on Jaffa oranges stated that as by the time taken for development of 10 per cent waste, storage at vas preferable to storage at 50°F. Early season (November) fruit was usceptible to rotting by green mould than the late season (March and uit. Fiddler and Tomkins [1938] found that dipping oranges in 2 per odium hydroxide was as effective as 5 per cent borax and leads to less to skin. One per cent borax plus one per cent sodium hydroxide were tive as 5 per cent borax alone. Vander Plank and others [1937, 1938] sized that the effect of temperature varied with the nature of fruit stored. mperatures 50-55°F. were beneficial for the storage of under-coloured nish oranges. At these temperatures the fruit coloured well in storage stage was as low as at 39°F. The fruit stored at 50°F. for about two s was liable to become stale while at 39°F. the flavour was well main- . Williams [1938] observed that the fruit stored in room at a tempera- 36-38°F. kept much better than that at lower or higher temperatures. ped fruit was better than unwrapped fruit. Karmarkar and Joshi found that percentage loss in weight of small fruit was always greater hat of big fruit except in case of grape fruit at 68°F. Rose and others recommended the use of 32-34°F. and 80-90 per cent humidity for the e of Washington Navel and Valencia Late oranges, at which storage life -10 weeks.

MATERIAL

wo important citrus fruits, viz. Malta orange (*Citrus sinensis*) and ra (*C. nobilis*) were included in the cold storage trials during 1938 and

Ialta oranges.—Five varieties of Malta orange, viz. Common, Blood Valencia Late and Seville were stored during 1938-39 and 1939-40. mbi was tried in 1940-41. Malta Common, widely cultivated, is a heavy r, and normally quite pleasant in taste. Blood Red is the choicest variety Punjab and is liked very much due to the red colour of its flesh, pleasant and agreeable aroma. Valencia Late is a late ripening variety, and sses good flavour. Seville is a heavy bearer. Musambi is popular with ids as it has very little acid.

Ialta Common and Blood Red were obtained from S. Mangal Singh's en near Shahdara, Lahore, in the beginning of March ; Valencia Late from ndian Mildura Fruit Farms Ltd. Renala Khurd, in the second week of and Seville was obtained from the Experimental Fruit Garden at Lyall- both the seasons in January. Musambi was obtained from Montgomery yallpur districts during the second week of January.

Sangtra oranges.—Sangtra is most commonly cultivated in the] the fruit is puffy or loose skinned and is easily damaged. The fruit is acidic (0·92 gm. citric acid per 100 c.c. juice) but when mature, is quite sant in taste. Two lots of Sangtra, one from Pathankote side and the from Lyallpur, were tried during the two years of the investigations.

The cold storage plant

The cold storage plant is designed for carrying out experiments on a scale. The outer dimensions of the plant are $14\frac{3}{4}$ ft. × $7\frac{1}{2}$ ft. × $7\frac{3}{4}$ ft. an a storage capacity of one and a half tons. It consists of three small cha designed to maintain three different temperatures (Plate XXX, fig. 1). chambers are at present being cooled by cool air circulated by a fan ov cooling coils. Each chamber is divided into four compartments and compartment is fitted with three removable shelves. Individual cham served by an independent compressor-motor connected to a thermo switch. There is an ' air-lock ' $4\frac{1}{2}$ ft. × $2\frac{1}{2}$ ft. × 7 ft. for each chamber.

Di-chloro-di-fluoro-methane commercially known as Freon or F- used as refrigerant. It is non-inflammable and non-poisonous.

The plant was installed at the end of October, 1937. Since then additions and alterations have been effected to get a closer and uniform of temperature. Most of the changes have been in direction of electric in tions done to get different speeds of circulating air. The diagrams of the tric installation in the beginning and at present are given in Fig. 1. the present arrangements it is possible to control the air speeds, both wh compressor is working and when it is at rest. These controls are adju according to the requirements as to whether higher speed is required wh compressor is working or when it is at rest. This arrangement helps to mize the fluctuations at the top and bottom of the chambers.

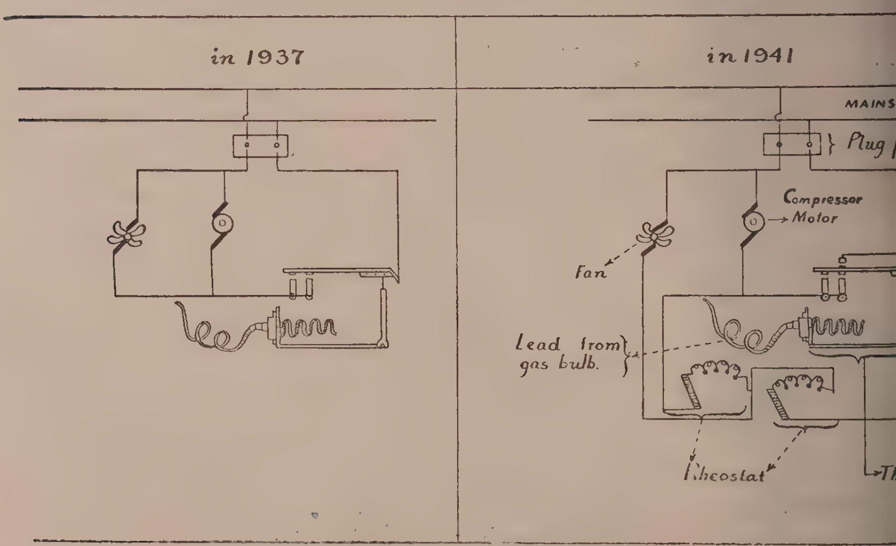


Fig. 1. Plan of electric installation in the cold storage plant

FIG. 1. Cold storage plant at Lyallpur

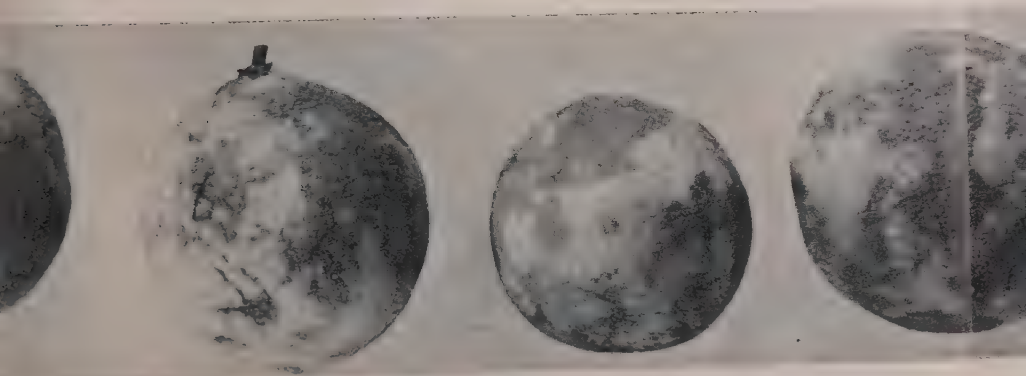


FIG. 2. Chill-spot injury of fruit

Method

he experiment was arranged to study the effect of size of fruit and nt temperatures upon the storage life of different varieties of Malta angtra oranges.

he fruit was graded into two sizes, viz. large and small. The diameter ;e fruit varied from 7·2 cm. to 8·9 cm. and small fruit from 6·0 cm. to n. Half the number of fruits of each size was wrapped with butter-paper ie other half kept unwrapped. The fruit after wrapping was subjected to nt ranges of storage temperature. The ranges of temperature in nt chambers during the first trial were 24°-32° F., 36°-39°F. and °F. But the fluctuations were reduced to a closer limit due to the sion of more piping and improvement in the air circulation, different ratures ranged as 29°-32°F., 36°-39°F. and 40°-43°F.

he number of fruits used under each treatment (viz. three temperatures, zes and two wrappings) was 72 and the fruits were arranged in two rows n trays. The trays were fitted with wooden splints at the base.

Losses in weight of fruit

'or the purpose of determining the loss in weight during storage six addi- fruits under each treatment were numbered and weighed individually tnightly intervals.

Other physico-chemical analyses

)bservations in case of all the varieties stored were made on the general tion of the fruit after every two weeks. Percentage weights of peel and ble juice were recorded as well as acid and sugar (total soluble solid) nt of the juice determined [Trout *et al.* 1938] at four-week intervals. Four were taken at random from each sub-lot at each occasion and the juice xtracted with the help of an electric driven 'Rose's cone' and then ed through a muslin piece with hand press.

torage life. The fruit was considered properly stored so long as the wast- d not exceed 10 per cent.

Ceeping quality of fruits after removal from cold store. Occasionally four stored at each temperature were taken out of the cold store and placed m temperature to study their keeping quality after removing from cold

tudy of rot organisms. A study of rot organisms was made and identi- n carried out.

Results

he results obtained in case of Malta and Sangtra oranges and even of ent varieties of Malta orange are in general the same excepting their e life. Consequently the data mainly of one variety, viz. Common of other varieties wherever necessary) are presented to economize space. ata relating to storage life of different varieties of Malta and Sangtra e are given in each case. The temperature range of 29°-32°F. being tely unsuitable for the storage of oranges due to the development of spots, the data at this temperature range were not collected.

Effect of storage temperature, size of fruit, wrapping and pe of storage

General condition and wastage of the fruit

At 29°-32°F. the fruit developed chill spots (Plate XXX, fig. 2) couple of weeks in storage. The spotting was invariably accompar deterioration in taste to a varying degree which ranged from flat-wa bitter and abnoxious. Even fruit, without chill spots at this tempe deteriorated in taste. This deterioration in taste was more marked wh fruit was placed at room temperature (90°-100°F.) for a few hours. Chi trouble was the least in case of Valencia Late and the most in Blood Re

36°-39°F. proved to be the best range of temperature for the stor Malta and Sangtra oranges. Malta Common at this temperature kept in lent condition for four months (Table I), Blood Red for three months, Va Late for four and a half months, Seville for three months and Musam $2\frac{3}{4}$ months (Fig. 2). Sangtra from Lyallpur and Pathankot kept in ex condition for seven weeks in 1938 but the storage life was reduced to fi four weeks respectively in 1939 as the fruit was subjected to greater a of handling and was not carefully picked and packed by the grower.

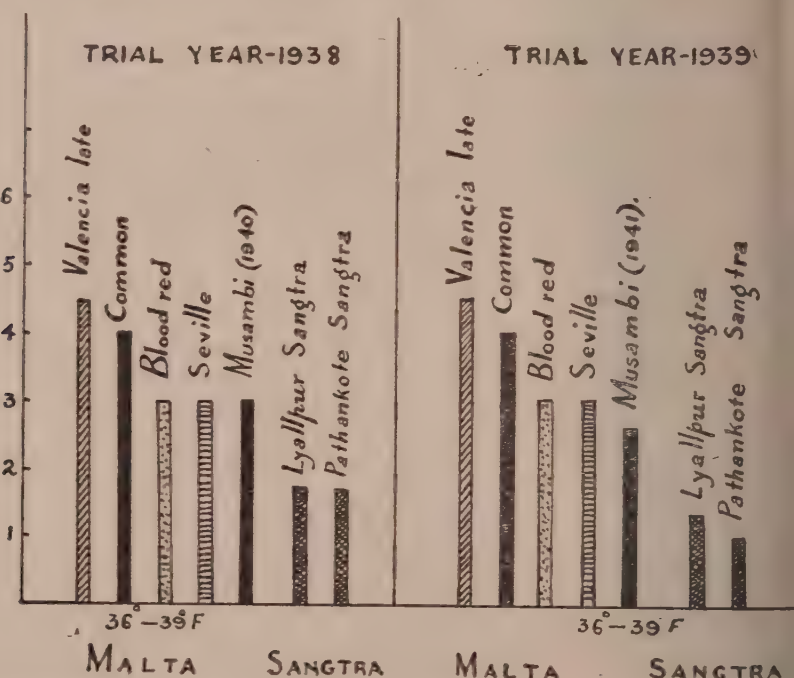
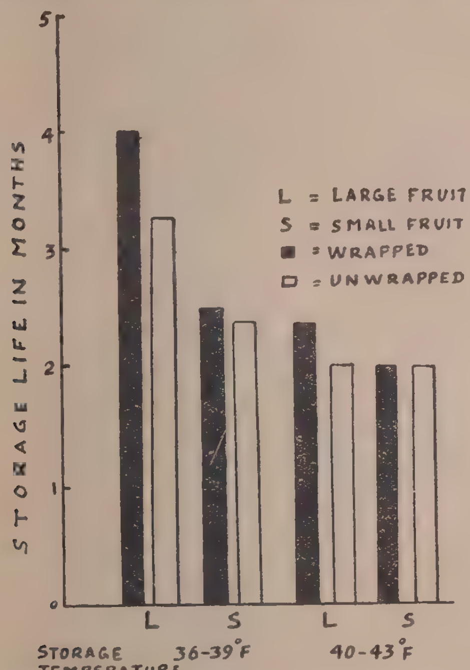


FIG. 2. Showing the maximum cold storage life of different varieties of Malta and Sangtra under optimum conditions

; storage life of the Malta orange of different varieties was reduced at
?. both due to fungal attack and shrivelling.
; size of the fruit had considerable effect on the storage life of the fruit,
ed fruit kept in good condition for a longer period as compared to small
ig. 3).
all fruits presented shrivelled appearance earlier than the large fruits
age life was thus considerably shortened in case of small fruits (Table I).
y, wrapping the fruit with butter paper proved to be beneficial in pre-
the colour, brilliancy and freshness of the skin of all the varieties tried.



Showing the storage life of Malta common fruit under different treatments

WEIGHT OF FRUITS (Tables II, III, IV & V)

; per cent total loss in weight of fruit (calculated on original fresh
of fruit) was determined from time to time. It was observed that the
eight increased with the advance in storage period. The loss in weight
greatest at 40°-43°F. and the least at 29°-32°F. and unwrapped fruit
e weight than wrapped one. Similarly, small fruit lost comparatively
ight than large one. At the end of four months storage the total loss
t of fruit under optimum conditions (large wrapped fruit, stored at
F.) varied from 18 per cent (in Valencia Late) to 25 per cent (in Com-
lta). Blood Red lost 25 per cent of its weight after three months
II).

PHYSICO-CHEMICAL CHANGES

Physico-chemical analyses of fruit were carried out for per cent of peel, per cent weight of juice, acidity and total soluble solids.

TABLE I

Showing the effect of temperature, size of fruit, wrapping, and period of on the per cent rate of wastage of fruit, of Malta Common orange

(Calculated on the actual number of fruits in storage)

No. of days in storage	Large				Small		
	Wrapped		Unwrapped		Wrapped		Unwrap
	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.
0 . . .	0	0	0	0	0	0	0
30 . . .	0	2·78	1·39	4·16	0	1·39	0
45 . . .	0	0	1·52	0	1·49	0	0
60 . . .	0	3·07	1·54	4·69	1·52	3·03	1·49
75 . . .	0	10·30	0	18·70	6·66	35·60	9·84
90 . . .	1·54	9·61	5·08	17·40	17·87	13·16	23·64
105 . . .	3·57	54·78	33·30	72·72	58·55	...	67·50
120 . . .	7·40	...	17·65	...	75·0	...	66·60

Showing the effect of ... *Malta Common orange fruit*

(Calculated on original fresh weight)

No. of days in storage	Large						Small					
	Wrapped			Unwrapped			Wrapped			Unwrapped		
	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.
0	0	0	0	0	0	0	0	0	0	0	0	0
30	2·6	4·15	5·15	3·22	5·33	6·10	3·04	4·84	5·82	5·16	6·45	7·00
45	...	8·63	9·04	...	9·88	10·13	...	9·97	8·71	...	10·72	12·08
60	...	12·82	14·27	...	13·35	14·20	...	14·50	15·20	...	15·23	16·71
75	...	19·80	22·40	...	20·18	23·40	...	21·48	22·35	...	22·10	24·20
88	...	21·72	27·50	...	23·32	28·10	...	23·50	27·38	...	25·0	29·10
104	...	24·05	32·00	...	26·57	33·50	...	26·02	31·50	...	28·66	34·82
120	...	27·10	35·87	...	29·83	38·37	...	31·48	35·94	...	33·30	41·70

Table III

Showing the mean per cent total loss in weight of large sized fruit of dif varieties of Malta orange under optimum conditions at the end of stora

Varieties	Storage life	Year 1938 36°—39°F. (per cent)	19 36°— (per
Common	4 months	25·5	27
Valencia Late	4½ months	19·1	17
Blood Red	3 months	25·5	21
Seville	3 months	22·6	21
Musambi*	2¾ months	23·5	19

* Musambi was tried during 1940 and 1941

Table IV

Showing the effect of temperature, size of fruit, wrapping and period of s on the per cent loss in weight of fruit of Blood Red orange

(Based on six numbered fruits)

No. of days in storage	Large				Small			
	Wrapped		Unwrapped		Wrapped		Unwrapped	
	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40
15	4·8	4·16	4·5	6·97	5·97	6·66	5·85	
30	11·77	12·50	9·10	11·65	11·65	13·58	16·67	
45	13·70	16·66	15·90	16·98	16·28	21·63	20·22	
60	17·64	20·92	18·18	21·93	20·94	24·02	24·22	
75	21·50	25·00	25·00	27·91	23·26	29·43	27·78	
90	25·48	29·17	31·80	39·53	27·91	35·43	36·10	
105	28·50	33·17	35·80	44·34	32·81	39·56	38·30	

TABLE V

wing the effect of temperature, size of fruit, wrapping and period of storage on the per cent loss in weight of fruit of Valencia Late orange

(Based on six numbered fruits)

o. of days in storage	Large				Small			
	Wrapped		Unwrapped		Wrapped		Unwrapped	
	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.
. . .	0·5	2·20	0·9	1·20	2·50	2·50	1·20	2·70
. . .	2·10	2·40	2·30	2·60	3·12	4·00	2·80	4·97
. . .	4·25	6·00	4·40	6·20	5·12	10·00	5·10	8·10
. . .	6·08	8·00	6·90	8·90	7·09	15·50	8·90	17·50
. . .	8·51	11·11	11·11	13·40	12·80	18·00	10·30	21·60
. . .	11·70	15·50	15·50	17·38	13·02	20·80	14·80	22·80
. . .	14·90	17·78	20·00	21·74	15·38	21·90	18·00	24·30
. . .	16·50	19·70	21·00	23·20	18·00	23·00	21·30	26·20

(*i*) *Per cent weight of peel* (Tables VI-VIII, Fig. 4). The per cent ght of peel was calculated on original fresh weight of fruit [Martin, 1937]. lecreased with the advance in the period and the decrease was more at -43°F. than at 36°-39°F. The per cent weight of peel was higher in large ts than in small ones to start with, and remained so throughout the iod of storage. The weight of peel decreased more in unwrapped fruits n in wrapped ones.

(*ii*) *Per cent weight of available juice* (Tables IX-XI, Fig. 4). Figures available juice in the fruit were calculated on the original fresh weight he fruit [Martin, 1937]. The per cent weight of juice decreased with advance in the storage period. The fruits stored at 36°-39°F. had her juice content than those at 40°-43°F. after a storage of four months. ll fruits had higher juice content than large ones, at the beginning of age, but lost more weight of juice than large ones at the optimum storage perature, i.e. 36°-39°F. Wrapped fruits had higher juice than unwrapped ts.

(*iii*) *Acid and total soluble solid contents of the juice* (Tables XII and I). The acid and total soluble solids decreased during the period of age when calculated on the original fresh weight. Other treatments,

viz. size, wrapping and temperature did not exhibit any marked difference the total soluble solid content though acid contents at 40°-43°F. were lov than that at 36°-39°F. after four months storage.

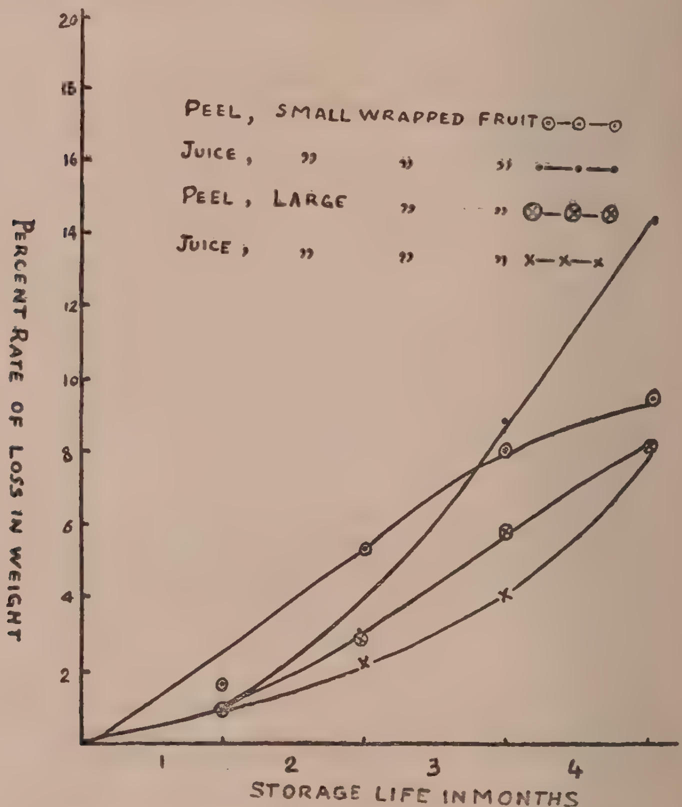


Fig. 4. Showing comparative loss in weight of peel and juice of Malta orange duri storage under optimum conditions

Fungal pathogens

Malta oranges

Chill spotting and deterioration in taste were mainly responsible for spo age at low temperature, viz. 29°-32°F. But at higher temperatures (36°-39° and 40°-43°F.) the wastage was mostly due to the fungal attack, viz. *Penicilli digitatum* and *P. italicum*. The first symptom was the softening of the tiss followed by a visible spread of the fungus. *Alternaria* sp. was also isolat from a few fruits. The fungus in this case was observed on the internal se ments of the pulp near the stem end. In 1939 storage trials, *Colletotrichu gleosporioides penzig* was also observed to cause the stem end rot.

Common orange fruit

(Calculated on original fresh weight)

No. of days in storage	Large						Small					
	Wrapped			Unwrapped			Wrapped			Unwrapped		
	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.
0	34·48	34·48	34·48	34·48	34·48	34·48	28·15	28·15	28·15	28·15	28·15	28·15
30	33·57	33·48	32·32	33·01	30·90	30·30	27·50	26·30	24·82	28·40	24·0	24·38
60	...	31·50	26·20	...	28·60	25·50	...	22·57	20·70	...	20·04	19·34
90	...	28·56	21·01	...	25·18	19·97	...	19·83	16·13	...	17·85	14·23
120	...	25·95	17·55	...	21·55	15·12	...	18·33	14·85	...	15·82	13·56

TABLE VII

Showing the effect of temperature, size of fruit, wrapping and period of storage on the per cent weight of peel of Blood Red orange fruit

(Calculated on original fresh weight)

No. of days in storage	Large				Small			
	Wrapped		Unwrapped		Wrapped		Unwrapped	
	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.
0	34·03	34·03	34·03	34·03	31·5	31·5	31·5	31·5
45	28·5	27·85	27·5	25·1	26·02	23·80	20·30	22·97
75	24·20	24·02	22·1	20·20	21·50	18·90	19·30	18·90
105	21·42	19·08	17·36	14·35	17·60	14·97	15·88	13·5

TABLE VIII

Showing the effect of temperature, size of fruit, wrapping and period of storage on the per cent weight of peel of Valencia Late orange

(Calculated on original fresh weight)

No. of days in storage	Large						Small					
	Wrapped			Unwrapped			Wrapped			Unwrapped		
	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.
0	34·52	34·52	34·52	34·52	34·52	34·52	29·78	29·78	29·78	29·78	29·78	29·78
30	...	34·00	34·68	...	32·58	32·20	...	27·78	28·20	...	27·30	26·90
60	...	30·02	29·64	...	28·77	29·28	...	27·40	24·24	...	26·78	23·08
90	...	28·59	27·82	...	25·34	26·98	...	25·10	21·22	...	24·88	19·19
120	...	26·20	22·48	...	24·12	17·28	...	21·45	19·20	...	19·90	16·64

TABLE IX

Showing the effect of temperature, size of fruit, wrapping and time of storage on the per cent weight of available juice of Malta Common orange fruit

(Calculated on original fresh weight)

No. of days in storage	Large						Small					
	Wrapped			Unwrapped			Wrapped			Unwrapped		
	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.
0	44·13	44·13	44·13	44·13	44·13	44·13	52·07	52·07	52·07	52·07	52·07	52·07
30	43·55	43·27	43·42	43·25	42·80	42·60	50·85	51·20	47·57	49·07	49·34	46·14
60	...	42·00	40·70	...	39·00	38·90	...	48·58	46·27	...	46·10	44·77
90	...	39·95	37·06	...	37·70	35·40	...	43·48	41·05	...	41·05	39·30
120	...	36·04	31·04	...	33·16	28·73	...	37·20	33·85	...	35·33	31·49

TABLE X

Showing the effect of temperature, size of fruit, wrapping and period of sto the per cent weight of available juice of Blood Red orange

(Calculated on original fresh weight)

No. of days in storage	Large				Small		
	Wrapped		Unwrapped		Wrapped		Unwrap
	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.
0 . . .	48·91	48·91	48·91	48·91	51·4	51·4	51·4
45 . . .	43·15	41·55	41·9	41·2	43·78	44·2	44·9
75 . . .	40·56	37·78	38·7	36·64	41·2	40·45	40·5
105 . . .	36·13	34·57	33·43	29·34	38·4	32·08	34·25

TABLE XI

Showing the effect of temperature, size of fruit, wrapping and period of st on the per cent weight of available juice of Valencia Late orange

(Calculated on original fresh weight)

No. of days in storage	Large				Small		
	Wrapped		Unwrapped		Wrapped		Unwrapp
	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.	40°-43°F.	36°-39°F.
0 . . .	48·7	48·7	48·7	48·7	52·77	52·77	52·77
30 . . .	49·0	46·4	46·5	46·36	53·1	52·0	52·5
60 . . .	48·4	47·20	48·2	44·6	50·14	46·4	48·7
90 . . .	45·09	44·8	44·37	44·6	47·02	45·10	46·5
120 . . .	44·73	42·5	42·2	41·7	47·0	45·4	45·2

TABLE XII

Showing the effect of temperature, size of fruit, wrapping and time of storage on the acid contents of Malta Common orange fruit

(Calculated on original fresh weight)

(Acidity given in grammes of citric acid per 100 c.c. juice)

No. of days in storage	Large						Small					
	Wrapped			Unwrapped			Wrapped			Unwrapped		
	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.	29°-32°F.	36°-39°F.	40°-43°F.
0	0·67	0·67	0·67	0·67	0·67	0·67	0·68	0·68	0·68	0·68	0·68	0·68
30	0·60	0·69	0·55	0·65	0·64	0·49	0·67	0·67	0·60	0·63	0·53	0·63
60	...	0·56	0·54	...	0·53	0·55	...	0·49	0·55	...	0·55	0·53
90	...	0·54	0·51	...	0·54	0·45	...	0·52	0·45	...	0·46	0·43
120	...	0·44	0·39	...	0·56	0·44	...	0·44	0·41	...	0·48	0·41

TABLE XIII

Showing the effect of temperature, size of fruit, wrapping and time of storage on the total soluble solids of juice of Malta Common orange fruit

(Calculated on original fresh weight)

No. of days in storage	Large						Small					
	Wrapped			Unwrapped			Wrapped			Unwrapped		
	29°-32°F. (per cent)	36°-39°F. (per cent)	40°-43°F. (per cent)	29°-32°F. (per cent)	36°-39°F. (per cent)	40°-43°F. (per cent)	29°-32°F. (per cent)	36°-39°F. (per cent)	40°-43°F. (per cent)	29°-32°F. (per cent)	36°-39°F. (per cent)	40°-43°F. (per cent)
0	9·30	9·30	9·30	9·30	9·30	9·30	9·80	9·80	9·80	9·80	9·80	9·80
30	8·57	9·30	9·58	8·33	8·08	9·58	9·31	9·70	9·79	9·84	8·60	10·88
60	...	8·11	8·32	...	8·14	8·95	...	8·72	9·16	...	9·15	10·26
90	...	8·45	7·97	...	8·43	8·62	...	8·29	7·99	...	7·80	8·02
120	...	7·29	8·08	...	8·11	8·01	...	8·75	8·20	...	7·85	8·68

ORANGES

angtra, in addition to blue and green moulds, another fungus s *niger* was also found on decaying fruits.

PING QUALITY OF THE FRUIT AFTER REMOVAL FROM COLD STORE

a oranges were occasionally removed from cold store and placed at perature (86°-110°F.) to see the keeping quality of the fruit after from the cold store. It was observed that the keeping quality of oom temperature was dependent upon the period of storage and the ure of the room at which the fruit was stored. The longer the period, was kept in cold store, the shorter was its keeping quality. Again r the room temperature at which the fruit was placed after removal cold store, the shorter it kept in marketable condition. The observa- given in Table XIV.

TABLE XIV

temperature and period of storage on the keeping quality of Malta orange fruit after removal from cold store

m ture at e fruit aced	Period of storage after which the fruit was removed from cold store	Storage temperature of fruit	Keeping quality of fruit after removal from cold store
	1 month	40°-43°F. 36°-39°F. 29°-32°F.	12 days 12 days 2 days in case of unfrozen fruit. Fruit bitter
F.	2 months . .	40°-43°F. 36°-39°F. 29°-32°F.	10 days 7 days Fruit bitter in taste
F.	3 months . .	40°-43°F. 36°-39°F.	5 days 5 days
F.	4 months . .	36°-39°F.	3—4 days
F.	4½ months . .	36°-39°F.	2—3 days

DISCUSSION OF THE RESULTS

he present investigations the best range of temperature for the storage and Sangtra oranges was found to be 36°-39°F. (air temperature of chamber). As already mentioned under 'review of literature', the of various workers as to the optimum temperatures for storage of vary from 32°-50°F., depending upon various considerations. While ns above and below the recommended temperatures are bound to ue to different kinds and varieties of citrus fruits, difference in soil, , cultural operations, age of trees, stage at which fruit is picked, care

in handling and storage conditions, etc. yet, 36°-39°F. temperature
taken as quite safe for the storage of Malta and Sangtra oranges un
Punjab conditions.

At the lower temperature range (29°-32°F.) the fruit showed signs
collapse—a malady known as 'chill spot' injury of the fruit. Th
thus affected lost its market value. In addition to this, the fruit at th
perature tasted bitter, probably due to the liberation of the bitter prin
oranges the 'Limonin' [Higby, 1941].

At higher temperatures (40°-43°F.) the storage life of the fruit w
siderably shortened due to the appearance of fungal diseases and shri
of the fruit.

The size of the fruit is an important factor in determining the stor
of the fruit. The present investigations reveal that large sized fruit kep
longer and in better condition and lost less weight than small sized fruit
is in conformity with the results obtained by other workers referred to
'review of literature'.

Wrapping the fruit with butter-paper proved beneficial in reduci
loss in weight of fruit and also preserved the brilliancy and freshness
fruit. No 'suffocation' of the fruit resulting in deterioration of t
mentioned by Williams [1938] was observed in wrapped fruit as th
covering of the butter-paper was not so air-tight as to compeletely obstr
exchange of gases. Another advantage of wrapping the fruit was t
fruit getting diseased remained isolated from healthy ones. Wrapping
fruit has also been recommended by other research workers, refer
under 'review of literature'.

The storage life of different varieties of Malta orange was found t
considerably. Malta Common kept well for four months, Valencia L
months, Blood Red three months, Seville three months and Musambi 2¾
under optimum conditions of storage (36°-39°F.). The study of literat
the subject reveals that storage life of even the same variety, varies
different conditions and thus no absolute limit can be laid down as
actual storage life of the fruit. The present investigations, therefore, in
the limits around which the storage life of a particular variety would o
as the extent of storage life is influenced by so many factors, a
mentioned.

The storage life of the Punjab Sangtra orange was considerably
(4-7 weeks) than Malta orange which is probably due to the 'puffy' na
the fruit, which makes it liable to damage very easily in transit or in ha
The storage life of King orange has been reported to be 50 days at 45°F.
Nagpur orange 90 days at 40°F. but these varieties are not cultivated
Punjab and are far more tight skinned than the Punjab Sangtra orange

Physico-chemical analyses of the fruit showed that the loss in weig
both from peel and juice during the storage period. In the beginning
storage life, peel lost weight to a greater extent than the juice, while at t
of the storage life reverse was the case. This probably is due to the fa
peel being more turgid in the beginning, readily lost its moisture bef
juice could be affected. Small fruits lost more weight than large ones
been observed by other workers, also, referred to under 'review of liter

ıis is due to the fact that in small fruits, the surface exposed per unit of ›lume is more than in large fruits.

The acid and total soluble solid contents of the juice were not affected in 'oportion to the decline in taste and consequently only acid and total soluble lid contents cannot be true index of quality. The acid and total soluble ·lids showed a decrease during the period of storage when calculated on ·iginal fresh weight and this is also observed by other workers cited under ·eview of literature '.

Fruit removed from cold storage and placed at room temperature showed ıat the keeping quality of the fruit at room temperature decreased with the lvance in the period of storage. This is probably due, partly to the rise in mperature of the room during summer and partly to low resistance of the uit to withstand high temperatures after prolonged storage at low temerature.

Summary

The investigations reported in the paper were carried out during 1938 ıd 1939 at Lyallpur under the Research Scheme on the Cold Storage of Fruits ı the Punjab, financed jointly by the Imperial Council of Agricultural Rearch and the Punjab Government. Results of investigations on Malta (*Citrus nensis*) and Sangtra (*C. nobilis*) obtained during the above period may be ımmed up as under :—

1. Five varieties of Malta, *viz*. Valencia Late, Common, Blood Red, Seville ıd Musambi and Sangtra from two localities namely Lyallpur and Pathankot ere stored at three storage temperatures, *viz*. 29°-32°F. 36°-39°F. and)°-43°F. Large and small fruits of each variety were used. Half of the uit was wrapped with butter-paper and the other half stored as such.
2. Physico-chemical analyses were carried out at regular intervals.
3. The best temperature range for the storage of citrus fruits (Malta and ıngtra) was found to be 36°-39°F.
4. The storage life of Malta (*C. sinensis*) varied with varieties, (*a*) Valencia ıte kept in good condition for $4\frac{1}{2}$ months, (*b*) Common for four months, (*c*) Blood ed for three months, (*d*) Seville for three months and (*e*) Musambi for $2\frac{3}{4}$ onths.
5. Loose skinned Sangtra from Lyallpur and Pathankot kept in good ndition for five and four weeks respectively.
6. Large fruit kept longer and in better condition than small fruit.
7. Wrapped fruit presented better appearance in regard to its colour ıd freshness and had higher juice content and lower wastage than unwrapped uit.

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CAJANUS OBCORDIFOLIA SINGH
A NEW SPECIES OF *CAJANUS*

BY

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(Received for publication on 19 May 1941)

(With six text-figures)

'*AJANUS* is a monotypic genus, represented in India by the only species *Cajanus cajan* Millsp. (*Cajanus indicus* Spreng.—Hindi—*arhar*). The ɔ sub-species are *C. indicus flavus* and *C. indicus bicolour*, the differentiation ng based on the colour of the flower and the habit of the plant. This plant extensively cultivated in the Gorakhpur district of the United Provinces. December 1939 the senior author noted in one of the *arhar* fields a plant ich was distinctly different from the others, and yet, it appeared to resemble *janus*. At that time all branches except one were flowerless. The plant s allowed to seed, which was later on collected and brought to Cawnpore and wn in the Botanical Garden of the Agricultural College. For comparison a ɔt of normal type of *arhar* was also sown.

All the plants of this new type, which were about 50 in number, repeated thout exception the characters of the mother plant. The chief characters the new type of *arhar* and that of the normal *C. cajan* Millsp. are summarized Table I given below :—

TABLE I

Character	*Cajanus cajan*, Millsp.	*Cajanus* (New type)
aflets .	Trifoliate .	Trifoliate
ape .	Lanceolate .	Obcordate
ɔex .	Acute to slightly acuminate .	Retuse and mucronate
andular hair .	Numerous and prominent .	Comparatively very few
ower petals .	Yellow .	Yellow ; lighter in colour
ɔel .	United at the top .	Quite free in open flower, filiform and usually appendaged
æ .	Lobes one sided and asymetrical with a pronounced peg-like out-growth at the base ; veins more prominent.	Lobes present on both the sides and hence symmetrical in shape, with a less pronounced peg-like out-growth at the base ; veins comparatively inconspicuous

It is evident from the comparative description that the new type dif from the normal type in having small and obcordate leaflets with retuse mucronate apices, while the normal type has oblong lanceolate leaflets (Fig and 2). On the basis of 100 observations made regarding the central leaf the following interesting data have been obtained and are shown in Ta II and Fig. 3.

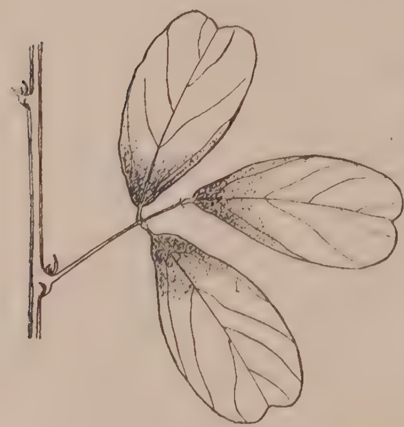


FIG. 1. Showing *Cajanus* (New type)

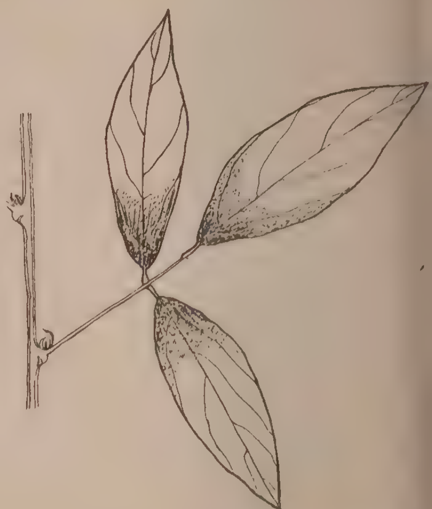


FIG. 2. Showing *Cajans cajan* (L.) Millsp. (*Cajanus indicus* spreng.)

TABLE II

Name	Variation in the length of central leaflets in mm.	Mean length of central leaflet in mm.	Variation in the width of central leaflets in mm.	$\frac{\text{Length}}{\text{Width}}$ rat
C. cajan	89-110	97·2	35-43	2·3-2·8
C. obcordifolia	63-76	68·6	31-40	1·5-2·1

The structure of the flowers is also very different ; the keel in the new t of *arhar* is free and represented by two filiform lobes usually appendaged w in the normal type the lobes are broad and united at the top (Figs. 4, 5 & The alæ or wings in the normal type are one-sided and asymmetrical havin very pronounced peg-like outgrowth at the base, whereas, these in the new t are symmetrical having lobes on both the sides with a less pronounced peg-l out-growth.

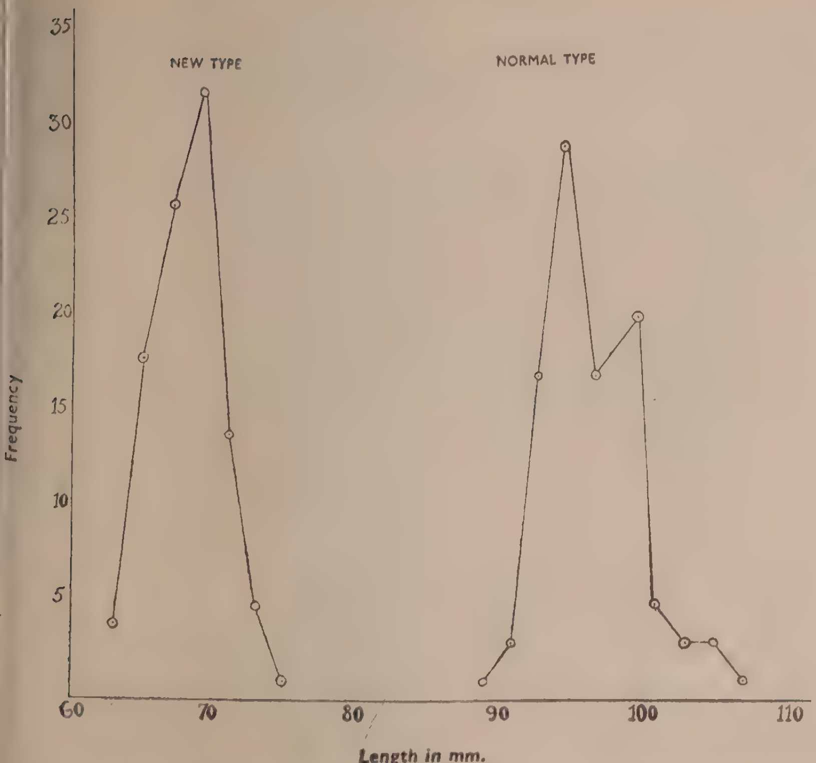
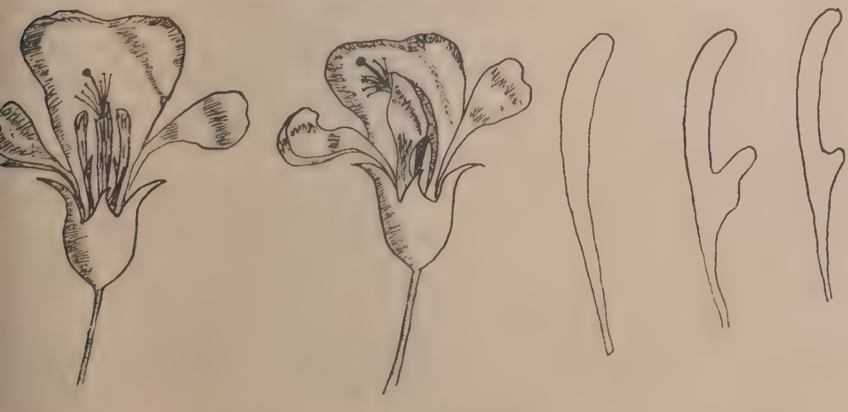


FIG. 3. Showing frequency distribution of central leaflet length in normal and new type



Keel petals free Keel petals united Keel petals new type

FIGS. 4, 5 and 6. Showing the structure of flowers of *Cajanus* (New type) and *Cajanus cajan* (L.) Millsp. (*Cajanus indicus* Spreng.)

According to analytical key given by Bailey [1924] the plant shoul long to the genus *Cajanus*. The description of *Cajanus indicus* Spreng., by Hooker [1875] states that the leaflets are oblong—lanceolate ; Bailey that they are lanceolate to narrow—elleptical. Hooker's classificati silent about the keel, while Bailey describes it as 'obtuse and incurved'. keel is a very distinctive character of Leguminosæ—Papilionaceae. Had deviation from the normal keel been noted in *Cajanus cajan* it would have emphasized. But so far no reference in the literature on the subject is to this fact.

During the course of above investigation, a study of the chromo number of this new type was also made. Aceto-carmene smears of mother cells were prepared for determining the gametic chromosome num Buds of about 3 mm. in length were found to be the best for the study meiotic chromosomes in the pollen mother cells at the first metaphase. haploid number of chromosomes was found to be eleven.

The study of the somatic chromosomes from the root-tips of the germ ing seeds was also made. The root tips were fixed in Flemming's cl osmium-acetic combination (weaker solution) and after the usual process embedding and cutting, the sections were stained by Newton's Ge Violet Iodine method and mounted in Canada balsam. The numb somatic chromosomes was found to be $2n=22$.

This new type of *Cajanus* may be the result of gene-mutation. Fu investigations on other features of genetical and cytological interest a progress. In the meanwhile owing to certain marked differences in veget and floral characters in this new type of *Cajanus*, it may be considered as species and is tentatively named as *Cajanus obcordifolia* Singh after its distinguishing character, *viz.* the obcordate shape of the leaflet.

Botanical description of *Cajanus obcordifolia* Singh. in English

Plant : . . .	**Erect and shrubby**
Root : . . .	**Tap ; fibrous and branched**
Stem : . . .	**Erect ; woody ; cylindrical and ribbed with many sl sulcate and grey silky branches**
Stipule : . . .	**Minute ; lanceolate ; fugacious**
Leaf : . . .	**Alternate ; compound ; imparipinnate ; with channele petiole ; trifoliate**
Leaflet : . . .	**Stalked, minutely stipellate, reticulate, obcordate with and mucronate apex ; margin entire ; glabrous ; deep above and whitish and pubescent below**
Inflorescence : . .	**Indefinite ; corymbose raceme ; often forming a termina cle**
Flower : . . .	**Irregular ; hermaphrodite ; pedicellate ; pedicels pr hairy and two to three times the calyx. The floral b a crumpled tip and not unoften there is an opening extreme tip**
Calyx : . . .	**Gamosepalous ; campanulate ; persistent ; glandular ; cent ; teeth short ; inferior**

ı : . . .	Irregular ; polypetalous ; papilionaceous ; more thant wice as long as the calyx ; perigynous ; standard yellow ; alæ or wings with lobes on both the sides and more or less symmetrical in shape ; peg-like outgrowth (auricle) at the base less pronounced ; clawed ; veins inconspicuous. Keel petals light in colour ; Quite free in open flower ; filiform and usually appendaged
·cium : . .	Ten in two bundles (9) +1 (diadelphous) ; not enclosed in keel in open flower ; anthers uniform. These dehisce in the bud even before the flower has reached its maximum size. This early dehiscence in this type may be due to the small opening at the tip resulting in greater loss of moisture from the anther walls
cium : . .	Monocarpellary ; subsessile ; few ovuled ; superior ; with a long filiform and upcurved style ; stigma capitate ; ovary wall pubescent ; pod with conspicuous black splashes (markings) ; beaked and constricted between the seeds ; hairy; seed exalbuminous ; compressed ; smooth and of light colour

nical description of *Cajanus obcordifolia* Singh. in Latin

nus obcordifolia Singh. sp. nov.

Frutex erectus. Radix principalis fibrosa et ramosa. Truncus erectus us, cylindricus et multis tenuibus, sulcatis et cinereo-sericeis ramis costatus ıli minuti, lanceolati, decidui. Folia alterna, composita, imparipinnata ı sulcato petiolo praedita, trifoliata. Foliola petiolata, minute stipellata rdate, apice retuso et mucronato ; margine integra ; superiore facie glabra ılde viridi, inferiore vero albescente et pubescente. Inflorescentia inde-, corymbose racemosa ; sæpe terminaliter paniculata. Flores irregulares, ıaphroditi, pediculati ; pediculi profuse pilosi, et bis vel ter calyce longiores. s gemma est corrugata apice et non raro in extremo apice foramine præ- Calyx gamosepalus, campanulatus, persistens, glandulis praeditus scens, inferior ; calycis dentes breves. Corolla irregularis, polypetala, ionacea, plus bis longior calyce, perigyna ; vexillum flavum ; alæ lobatæ roque latere et plus minus symmetricæ forma ; auricula clavo similis in minus conspicua ; petala ad basim tenuescentia ; venæ insconspicuæ. ıæ petala colore claro, omnino libera in aperto flore, filiformia et sæpe ıs appendiculata. Andrœcium ; stamina diadelpha (9 + 1) ; non inclusa ırina in aperto flore ; antheræ uniformes, dehiscentes in gemma etiam quam flos maximam magnitudinem attigerit. Præmaturæ huius dehis-æ causa forte sit parvum illud foramen in apice gemmæ, quod efficit ut eræ parietes majorem humiditatis quantitatem amittant. Gynœcium ocarpum, sudsessile, superius, paucis ovulis et stylo longo filiformi et ım curvato præditum ; legumen conspicuis nigris maculis ornatum, ros-m et constrictum inter semina ; pilosum. Semen exalbuminatum, com-um, planum vel læve et colore clarum.

Acknowledgements

Our thanks are due to Dr T. S. Sabnis, I.A.S., Economic Botanist to ernment, United Provinces, and Principal, Agricultural College, Cawnpore,

and Mr P. R. Mehta, Assistant Professor of Botany, for their helpful tions, and to Mr. T. R. Mehta for his unfailing interest and kind criticism the course of the above investigation. We feel greatly indebted to I Santapau of the St. Xavier's College, Bombay, for the Latin descriptio new species.

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RESEARCH NOTE

CHROMATIN BRIDGES IN COTTON*

BY

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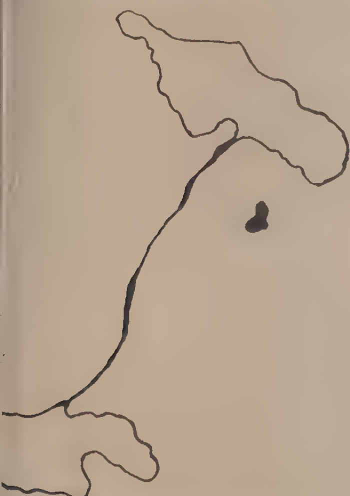
(Received for publication on 7 January 1942)

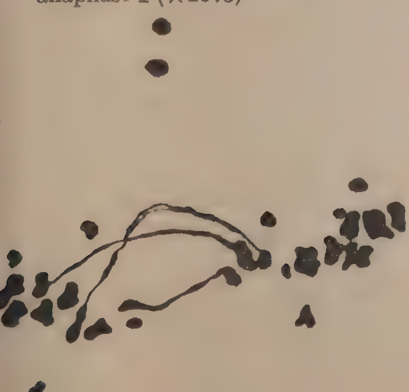
(With four text-figures)

)MATIN bridges were noticed at anaphase I, metaphase II and ana-
ıe II of meiosis (Figs. 1-4) in F_1 triploid hybrids between Asiatic and
ın cottons shown in the table on the next page.



1. A bridge and a fragment at anaphase I (×2375)

FIG. 2. A bridge at metaphase II (×2750)



3. Three bridges at metaphase II (×2375) (all chromosomes not shown)

FIG. 4. A bridge and a fragment at anaphase II ×2750)

his research is being financed from the funds of the Indian Central Cotton Com-

Hybrid No.	Parents	
	American	*Asiatic*
S 29-1 . .	*G. barbadense L* (Sea Island)	*G. herbaceum* var. *frutes* (Surat 1027 A L F)—Delile
S 31-3 . .	,,	,,
S 38-1 . .	,,	,,
S 37-1 . .	*G. hirsutum L* (Coimbatore 2)	,,

These bridges are clearly seen in acetocarmine smears of the flower l at metaphase II (Figs. 2 and 3). The number of such bridges at this s varied from one to four per nucleus, indicating that structural changes l taken place in more than one bivalent. The bridges are very similar to t figured by Miduno [1940] in the orchids and Srinath [1940] in the g *Calceolaria*.

The formation of bridges at anaphase have been reported by Bea [1940] in the F1 hybrid between *G. thurberi* Tod. × *G. arboreum* var. *negle* H. & G., and by Ramiah and Gadkari [1941] in a sterile mutant of a stra Asiatic cotton (*G. arboreum* var. *neglectum* forma *burmanica* H. & Beasley [1940] has also pointed out that such bridge formations give evid of structural differences between the chromosomes of the species invo in his cross. That definite structural changes, like inversions and tr locations could have taken place in cotton has been pointed out by J [1941], where he shows one of the two chromosomes with a lateral satelli the root-tip of *G. herbaceum* and *G. arboreum* and a ring chromosome in root-tip of *G. herbaceum* var. *africanum* H. & G., at the metaphase st Further evidences that definite structural differences do exist between chromosomes of certain species of cotton are pointed out in this note.

The formation of bridges may be due to several causes as invers translocations and duplications [Richardson, 1936]. A critical analysi both metaphase and anaphase at division I is necessary to enable us to what conditions have given rise to observed results and which of the struct changes that are possible have taken place. In the hybrids that are exam in the present study no abnormal configurations at metaphase I, as une bivalents etc. could be clearly made out. The bridges that are seen at m phase II are long and thin and their persistance at this stage shows that bridges formed at anaphase I are not broken. The fragments that arise w such bridges are formed are difficult to make out in all the cases. The forma of a bridge at anaphase II, in one of the sister cells (Fig. 4), undoubtedl dicates that a loop chromatid must have been formed at anaphase I, as a re of an inversion pairing and two cross-overs having taken place, one in inversion region and one in the region proximal to it, in which only one c matid is involved in both the cross-overs. A monocentric loop and a fragn would be formed at anaphase I. The loop chromatid forms a bridge at phase II, the centromere having divided.

The above points indicate that in the triploids under study, we not only l with mere numerical changes but structural changes as well. Both hese factors may contribute to the sterility of the hybrids. All the same structural changes lead to the formation of new chromosomes which may ve to be of evolutionary significance.

A fuller discussion of the above points will be published in due course.

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PLANT QUARANTINE NOTIFICATIONS

NOTICE No. 2 OF 1942

INDIA

THE following plant quarantine regulations and import restrictions have been received in the Imperial Council of Agricultural Research. Thos interested are advised to apply to the Secretary, Imperial Council of Agricul tural Research, New Delhi, for loan.

1. U. S. Department of Agriculture, B. E. & P. Q.

1. *Summaries of plant quarantine import restrictions.*

(*i*) Republic of Cuba—Revision of regulations.

(*iii*) Republic of Uruguay—Standards established for Certain seeds.

(*iii*) Br. Colony of Malta—Area quarantined on account of Colorad Potato Beetle increased.

2. *Service and Regulatory Announcements.*

List—October—December 1941.

II. Other Announcements.

Jamaica—Br. W. I.: Citrus fruits in ports.

Notification No. 69/C. No. 429-Cus. II/41, dated 20 December 1941 of the Govern ment of India in the Department of Finance (Central Revenues)

IN exercise of the powers conferred by section 19 of the Sea Custor Act, 1878 (VIII of 1878), the Central Government is pleased to prohibi with effect from 1 April 1942, the bringing into British India of bees or silk worms save where they are accompanied by—

(a) a special permit in accordance with the form set forth in the Schedul hereto annexed authorizing such importation issued by the Central Govern ment or by an officer authorized by the Central Government in this behalf and

(b) a certificate of freedom from disease granted by an Entomologis of the Government of the country of origin.

SCHEDULE

Form of special permit authorizing importation of bees or silk-worms

1. Name, designation and full address of the importer ....

....

2. Name of the species of bees or silk-worms to be imported ....

....

3. Stage or stages of the bees or silk-worms to be imported ....

....

4. Country from which importation is sought ....

....

Whether importation is intended by sea, land or air ....
....
Name, designation and address of the exporter ....
....
Quantity indented for ....
....
Purpose of importation ....
ne above information is true to the best of my belief

ate

(Signature of the importer)

authorize the importation. This permit willl be valid up to

ate

(Signature and designation of the certifying authority)

. B. It is expected that the permit will be obtained in advance of sending the o that the imported material may not remain indefinitely in the warehouse for f suitable permit.]

ication No. F. 15-21/41-A., dated 12 May 1941 of the Government of India in the Department of Education, Health and Lands

xercise of the powers conferred by sections 4A and 4D of the Destructive cts and Pests Act, 1914 (II of 1914), the Central Government is d to direct that the following further amendments shall be made in the ation of the Government of India in the Department of Education, n and Lands, No.F.50-13 (20) /39-A, dated 20 November 1940, and the published therewith, namely :—

I. In the preamble to the said notification, and in rule 1 of the said rules, after the word 'Punjab', the words 'the United Provinces' shall be inserted.

II. In the *Note* below the Schedule annexed to the said rules, clauses (*b*) and (*c*) shall be re-lettered as clauses (*c*) and (*d*) respectively and before clause (*c*) as so relettered, the following clause shall be inserted, namely :—

'(*b*) in the United Provinces, by the Entomologist to the Government of the United Provinces, or such other officer as may be authorised by the Provincial Government in this behalf'.

GN

e No. 1 of 1942 regarding plant quarantine regulations and import restrictions received in the Imperial Council of Agricultural Research

E following plant quarantine regulations and import restrictions have en received in the Imperial Council of Agricultural Research. Those sted are advised to apply to the Secretary, Imperial Council of Agricural Research, New Delhi, for loan.

LIST OF UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF ENTO LOGY AND PLANT QUARANTINE, IMPORT RESTRICTIONS, SERV REGULATORY AND OTHER ANNOUNCEMENTS

1. *Summaries of plant quarantine import restrictions.*—
   (i) Republic of Mexico.—Substitution of quarantines regarding co & banana
   (ii) Republic of Uruguay.—Restriction on the importation of seed tatoes
   (iii) Union of South Africa.—Revision of regulations concern tomato seed
   (iv) British Colony of Bermuda.—Amendment of banana prohibit
   (v) Colony of British Guiana.—Restrictions of coffee and paddy & prohibition of citrus

2. *Service and Regulatory Announcements.*—
   (i) List—April—June 1941
   (ii) Index—1940

3. *Other announcements.*—

Canadian Order.—in council enabling the Inspectors to withhold ce ficates of inspection.

Exports of potato to Mauritius

IT is notified for general information that exports of potato to Maurit must be accompanied by a certificate stating that the potatoes have b grown in a locality free from Potato Wart (*Synchytrium edoioeloticum*) a Colorado Beetle (*Leptinotarsa decemblineata*).

NOTE

article entitled 'Studies on the Formation of Jellies from some ɩn Fruits' by Birendra Narain Singh and Sikhibhushan Dutt pub- the *Indian Journal of Agricultural Science*, Vol. XI, Part VI, Dec-)41, pp. 1006-21, the authors claim to have discovered the jelley- qualities of wood apple in the following words :—'It has, however, ɩnd by the present investigators to be an excellent jelley-forming , being very rich both in acid and pectin.' It has now been brought ɩtice that the making of an effective wood apple jelly was first studied S. S. Bhat, Horticulturist to Government, Baroda, at the Baroda ɘservation Laboratory and the results published in *Rural India*, Vol. 3, arch 1940 (Editor).

—S 3—167 ICofAR—14-11-42—600.

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(October 1942)

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